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The Role Of Chronic Stress In Age Gradients Of Preterm Birth Among Racial/ethnic Groups

Sangmi Kim
University of Pennsylvania, greenrainsm@gmail.com

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Abstract
Recently, chronic stress has drawn great attention as an underlying mechanism of preterm birth (PTB) among racial/ethnic minority women. However, the association between chronic stress and PTB is not clearly understood. In fact, existing chronic stress models do not agree on definitions and assessments of chronic stress, rarely reflect racial/ethnic differences in chronic stress experiences, and overlook the cumulative nature of chronic stress over time.

The purpose of this dissertation was to determine if chronic stress before and during pregnancy explains the maternal age-graded PTB risk among four racial/ethnic groups of women (non-Hispanic [N-H] Whites, N-H Blacks, Hispanics, and Asians) in the U.S. Paper 1 is a systematic literature review that identified chronic stressors affecting adverse birth outcomes among the four racial/ethnic groups. Building on findings from Paper 1, Paper 2 examined factor structures of chronic stress unique to the four racial/ethnic groups through exploratory factor analysis. From this analysis, a race/ethnicity-specific composite index of chronic stress was developed as an operational definition of chronic stress for Paper 3. Paper 3 then investigated the moderating effect of maternal age on the chronic stress-PTB relationship stratified by race/ethnicity through logistic regression. Papers 2 and 3 implemented secondary analysis of the Pregnancy Risk Assessment Monitoring System for Washington State and New York City (2004-2007).

Paper 1 found that the extant chronic stress measures tended to be unstandardized, incomprehensive, independent, or universal across race/ethnicity, weakening the accuracy of appraised chronic stress for women in each racial/ethnic group. Paper 2 noted that the four racial/ethnic groups analyzed shared financial hardship, perceived isolation, and physical violence as significant sources of chronic stress, despite intergroup variations particularly in their physical violence experience. Paper 3 observed a maternal age-related increase in PTB (i.e., weathering) among all racial/ethnic groups (except for Asians) with high chronic stress in unadjusted and adjusted models. Experience of race bias exacerbated weathering among racial/ethnic minority women with high chronic stress.

This study will contribute to narrowing the racial/ethnic gaps in PTB through elucidating heterogeneity of the chronic stress mechanism among racial/ethnic groups and developing theory-driven, race/ethnicity-specific interventions to prevent exposure to chronic stressors and foster women's resilience over the life course.

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Sangmi Kim

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Supervisor of Dissertation

_____
Connie M. Ulrich
Professor of Nursing
Lillian S. Brunner Chair in Medical and Surgical Nursing

Graduate Group Chairperson

_____
Eileen T. Lake
Associate Professor of Nursing
Jessie M. Scott Endowed Term Chair in Nursing and Health Policy

Dissertation Committee

Connie M. Ulrich, Professor of Nursing, Lillian S. Brunner Chair in Medical and Surgical Nursing

Eun-Ok Im, Mary T. Champagne Professor of Nursing

Jianghong Liu, Associate Professor of Nursing

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AMONG RACIAL/ETHNIC GROUPS

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Connie M. Ulrich

Recently, chronic stress has drawn great attention as an underlying mechanism of preterm birth (PTB) among racial/ethnic minority women. However, the association between chronic stress and PTB is not clearly understood. In fact, existing chronic stress models do not agree on definitions and assessments of chronic stress, rarely reflect racial/ethnic differences in chronic stress experiences, and overlook the cumulative nature of chronic stress over time.

The purpose of this dissertation was to determine if chronic stress before and during pregnancy explains the maternal age-graded PTB risk among four racial/ethnic groups of women (non-Hispanic [N-H] Whites, N-H Blacks, Hispanics, and Asians) in the U.S. Paper 1 is a systematic literature review that identified chronic stressors affecting adverse birth outcomes among the four racial/ethnic groups. Building on findings from Paper 1, Paper 2 examined factor structures of chronic stress unique to the four racial/ethnic groups through exploratory factor analysis. From this analysis, a race/ethnicity-specific composite index of chronic stress was developed as an operational definition of chronic stress for Paper 3. Paper 3 then investigated the moderating effect of maternal age on the chronic stress-PTB relationship stratified by race/ethnicity through

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This study will contribute to narrowing the racial/ethnic gaps in PTB through elucidating heterogeneity of the chronic stress mechanism among racial/ethnic groups and developing theory-driven, race/ethnicity-specific interventions to prevent exposure to chronic stressors and foster women's resilience over the life course.

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PAPER 1

CHAPTER 1

Background

Evidence abounds in the United States (U.S.) of persistent disparities in adverse birth outcomes, such as preterm birth (PTB; < 37 weeks' gestation) by race/ethnicity, educational attainment, income, and neighborhood characteristics (Blumenshine, Egerter, Barclay, Cubbin, & Braveman, 2010; Culhane & Elo, 2005; Gavin, Nurius, & Logan-Greene, 2012). Especially for racial/ethnic disparities, the prevalence of PTB among non-Hispanic (N-H) Black (16.24%) and Hispanic (11.19%) women, respectively, is 1.6- and 1.1-fold the prevalence among N-H White women (10.08%) in 2015 (Hamilton, Martin, Osterman, & Division of Vital Statistics, 2016). However, mechanisms of these disparities remain unclear (Culhane & Elo, 2005).

An implicit but largely untested assumption underlying the pathways connecting race/ethnicity and adverse birth outcomes is that risk factors operate the same way across populations (Geronimus, 1996). Numerous risk factors, however, act jointly and interactively to explain racial/ethnic disparities in adverse birth outcomes. It is thus critical to explore interactions among predictor variables and between predictor variables and theorized mediators. Nevertheless, many prior studies have overlooked these types of interactive effects by taking simple approaches that examine main effects only (Giscombé & Lobel, 2005). One traditional risk factor that merits reconsideration is maternal age (Geronimus, 1996). In the existing literature, maternal age is commonly assumed to be an entrenched biomedical indicator, independent of other social factors including race/ethnicity and to confound the effect of race/ethnicity on adverse birth

outcomes. For this reason, the racial/ethnic gaps in adverse birth outcomes by maternal age have been less widely appreciated (Rich-Edwards, Buka, Brennan, & Earls, 2003).

Geronimus and Snow (2013) asserted that variations in the age dimension of health by social conditions (e.g., gender or race/ethnicity) provides a useful lens through which women's health risk is appreciated and intervened since social expectations, opportunities, and discriminations are age-graded, and their health effects are often cumulative. The weathering hypothesis (Geronimus, 1992) first reported the different age patterns of adverse birth outcomes between Black and White women, supporting an interaction of maternal age with race/ethnicity to affect birth outcomes. Weathering refers to health deterioration of Black women throughout the reproductive period as a result of physical insult from chronic stress that accumulates over the life course. Weathering of Black women manifests in their increasing risk of adverse birth outcomes at advancing maternal age. In contrast, White women show the opposite: lower risk in their 20s than in their teens. These two different age patterns result in the Black–White disparities in adverse birth outcomes compounded by maternal age. From the weathering perspective, maternal age does not just represent a mother’s biological or psychosocial preparedness for childbearing (Geronimus, 1996). Instead, a maternal age for underprivileged women including Blacks could be redefined as the duration of a woman’s experience of or exposure to life-long stressful conditions, which is assumed to accumulate with maternal age (Rich-Edwards et al., 2003). This new definition implies the interactive relationship between chronic stress and maternal age where an accumulation of stress may be indicative of the amplified chronic stress-effect with maternal age. By incorporating maternal age as not only biological but also psychosocial characteristic, the weathering

framework could provide an insight to interpret the life course progression in women's health, culminating into her birth outcomes through the chronic stress mechanisms, particularly for disadvantaged women.

Nevertheless, our understanding of weathering and its underlying mechanisms is limited for three reasons: First, conflicting findings regarding the effect of chronic stress on adverse birth outcomes are shown possibly due to inconsistent definitions of chronic stress and its assessment (Borders, Grobman, Amsden, & Holl, 2007; Hobel, Goldstein, & Barrett, 2008; Latendresse, 2009) as well as decontextualized chronic stress measures that fail to capture distinctive stressful experiences of racial/ethnic groups of women.

Second, although chronic stress has been theorized to explain the maternal age-related increase in adverse birth outcomes among disadvantaged women, efforts to empirically demonstrate the role of chronic stress in this phenomenon are lacking.

Third, weathering has been examined mostly among Black women by far, although stress accumulation lends itself to other racial/ethnic minority women, such as Hispanics and Asians. With no consensus on who is subject to weathering (e.g., all Blacks, only low-socioeconomic-status (SES) Blacks, or low-SES Whites as well; Geronimus, 1992, 1996; Holzman et al., 2009; Love, David, Rankin, & Collins, 2010; Rauh, Andrews, & Garfinkel, 2001), current weathering research focused on Black women may limit opportunities to elucidate the operation of chronic stress in weathering through the experiences of Hispanic and Asian women.

To fill these evidence gaps, this dissertation, through three interlinked studies, examined the role of chronic stress before and during pregnancy in the age gradients of PTB among four major racial/ethnic groups in the U.S.: N-H White, N-H Black,

Hispanic, and Asian women. Specifically, Paper 1 conducted a systematic literature review to identify and synthesize the known chronic stressors affecting adverse birth outcomes among racial/ethnic groups of women in the U.S. Paper 2 explored commonalities and differences in factor structures of chronic stress before and during pregnancy among the four racial/ethnic groups through exploratory factor analysis (EFA) to develop a race/ethnicity-specific composite index of chronic stress (i.e., chronic stress score). Based on the list of chronic stressors identified in Paper 1, the items of chronic stress for EFA were derived from the Pregnancy Risk Assessment Monitoring System (PRAMS) data for Washington State and New York City (2004-2007). Also, the race/ethnicity-specific chronic stress score was used in Paper 3 as an operational definition of chronic stress before and during pregnancy. Finally, Paper 3 investigated if maternal age moderated the effect of chronic stress on PTB stratified by race/ethnicity through logistic regression of the PRAMS data for Washington State (2004-2007).

Significance

Imperative public health agenda. The racial/ethnic disparities in PTB have been apparent for decades in the U.S. (MacDorman & Mathews, 2011). Although the PTB rates for N-H White, N-H Black, and Hispanic women from 2007 to 2015, respectively, declined by 12.3%, 11.3%, and 9.0% to 10.08%, 16.24%, and 11.19% (Hamilton et al., 2016; Martin, 2011), still N-H Black and Hispanic women were at greater risk of PTB than were N-H White women in the U.S. Asian or Pacific Islander (API) women in aggregate tend to report favorable birth outcomes over other racial/ethnic women with the PTB rate of 9.97% in 2015 (Hamilton et al., 2016). Some of the sub-ethnic groups,

however, experience higher risk of PTB than N-H White women after controlling for maternal risk factors (e.g., parity, nativity, age, marital status, and education; Alexander, Wingate, Mor, & Boulet, 2007; Singh & Yu, 1996).

Preterm infants experience the increased risk of death in the first year of life (D'Onofrio et al., 2013; McIntire & Leveno, 2008). Also, even late PTB (34-36 weeks' gestation) relate to various neonatal morbidities, including ventilator-treated respiratory distress, transient tachypnea, intraventricular hemorrhage, sepsis, phototherapy for hyperbilirubinemia, and intubation in the delivery room (McIntire & Leveno, 2008). Moreover, extreme PTB (23-27 weeks' gestation) is associated with the newborn's psychiatric, academic, and social outcomes, including autism (hazard ratio [HR] = 3.2 [2.6, 4.0]), low educational attainment (HR = 1.7 [1.5, 2.0]), and social welfare benefits (HR = 1.3 [1.2, 1.5]; D'Onofrio et al., 2013). More than just a concern for a single individual in a particular generational cohort, a mother's birth outcomes have been linked to those of her infant, suggesting that adverse birth outcomes can perpetuate across generations (American Public Health Association, 2006).

Besides, PTB and their sequels mentioned above have an enormous negative psychosocial and emotional effect on families (Saigal & Doyle, 2008). Parents of PTB infants are more likely than those of term infants to experience depressive symptoms, posttraumatic stress disorder, and family dysfunction (e.g., disruption of social/marital relationships, inappropriate parental coping, or financial difficulties; Treyvaud, 2014). Parenting stress resulting from caring for PTB infants is higher, particularly for those with low family income or less education (Saigal & Doyle, 2008; Treyvaud, 2014).

At a societal level, increasing PTB has significant implications for educational and medical services and their costs (Saigal & Doyle, 2008). The financial costs associated with treating preterm labor and delivery are quite high. The annual cost of prematurity in the U.S. was estimated to be more than $26 billion (2005 U.S. dollars; Institute of Medicine, Committee on Understanding Premature Birth and Assuring Healthy Outcomes, 2007). This estimate includes medical care costs of $16.9 billion; the remainder is composed of special education, early intervention, maternal healthcare costs, and changes in adult work productivity (Zupancic, 2007).

Chronic stress as a key predictor of adverse birth outcomes. Increasing attention has been paid to the role of psychosocial factors in the etiologies of adverse birth outcomes, such as stressful life events, perceived stress, anxiety, depressive symptoms, and chronic stress (McDonald, Kingston, Bayrampour, Dolan, & Tough, 2014). Much research has focused on the associations between adverse birth outcomes and both pregnancy-related stress and stressful life events during pregnancy (Kramer, Hogue, Dunlop, & Menon, 2011). Reportedly, however, checklist scores of stressful life events yield substantially biased estimates of total stress exposure across race/ethnicity, gender, and SES, at least among the young. Specifically, limiting stress measurement to a checklist of recent events has been shown to significantly overestimate total stress exposure among women compared to men and systematically underestimate such exposure among Blacks compared to Whites and among persons of lower SES compared to their more advantaged counterparts (Turner, 2010).

Instead, chronic stress has been suggested to better predict health problems than more dramatic, but less frequent, life events (Kramer et al., 2001; Strutz et al., 2014). Lu

and Chen (2004) argued that stressful life events did not significantly contribute to the racial/ethnic disparities in PTB because of not adequately measuring chronic stress that might be more pervasive in the lives of women of color. Similarly, Strutz et al. (2014) documented that preconception chronic stressors contributed to racial/ethnic disparities in birthweight and that chronic stressors had greater impact on birthweight than did acute stressors.

Nevertheless, the relationship between chronic stress and adverse birth outcomes is still obscure, which is attributable to differences among studies in how chronic stress was conceptualized, when chronic stress was assessed, and sample populations (Littleton, Bye, Buck, & Amacker, 2010). Therefore, understanding how chronic stress is operationalized among racial/ethnic groups of women in the literature is an essential step to thoroughly investigating the mechanisms by which chronic stress results in the excess PTB risk among racial/ethnic minority women (Witt, Litzelman, Cheng, Wakeel, & Barker, 2014).

Importance of cumulative stress measures. As a proxy for chronic stress, most research by far has focused on isolated stressors, although in fact multiple stressors often co-occur in an ecological context and may interactively influence health outcomes (Troxel, Matthews, Bromberger, & Sutton-Tyrrell, 2003). Wadhwa, Entringer, Buss, and Lu (2011) also asserted that distinction between various components or dimensions of psychological stress as discrete entities may be somewhat arbitrary because different components of psychological stress are not randomly distributed, but tend to occur simultaneously with one another.

Aggregating across multiple sources of stress may increase the predictive power of individual stress measures and may be a more valid representation of the stress process (Troxel et al., 2003). If a set of stress measures inter-correlates, their combined use as a measured variable or latent factor should increase the stress measures' quality and power to detect the effect of stress on reproductive outcomes (Dunkel Schetter & Glynn, 2010). Indeed, studies that have examined discrete measures of stress independent of their ecological context may underestimate real stress–disease relationships (Troxel et al., 2003). McDonald et al. (2014), for example, developed a cumulative psychosocial stress variable by incorporating anxiety symptomatology during pregnancy, feelings about the current pregnancy, and preexisting vulnerabilities to examine the association between the cumulative psychosocial stress and PTB. They reported that neither past psychosocial stress alone nor anxiety symptoms alone predicted PTB, but the composite variable that combined previous psychosocial stress and anxiety during pregnancy was indeed a significant risk factor. Therefore, developing a composite index of chronic stress, albeit with a limited number of proxy variables, would mirror the way individual chronic stressors operate, and thereby enhance an accuracy of the measured chronic stress.

Extension of the weathering hypothesis to diverse racial/ethnic minority groups. Weathering has been examined predominantly among N-H Black women in the literature, probably because of the disproportionately concentrated social disadvantages endured by this population in the U.S. Besides, small representations of Hispanics and Asians in collected data may have hindered exploring weathering in other racial/ethnic minority groups than N-H Blacks. Testing the weathering hypothesis among Hispanic and Asian women would show whether a maternal-age–related increase in adverse birth

outcomes manifests among populations across race/ethnicity exposed to high levels of chronic stress before and throughout the pregnancy.

Demographic changes in the U.S. childbearing population also justify an extension of the weathering framework to Hispanic and Asian women. First, the numbers of Hispanic and Asian mothers in the U.S. are growing over time. The share of births to Hispanic mothers increased from 14% to 24% from 1990 to 2008; during the same period, the proportion of births to Asian mothers increased from 3% to 6% (Livingston & Cohn, 2010). Second, childbearing has been delayed across racial/ethnic groups in the U.S. According to the National Center for Health Statistics (Matthews & Hamilton, 2014), over the past two decades first-birth rates rose for older women—women aged 35 and over—of all race and Hispanic origins. The largest increases from 2000 to 2012 were seen for N-H White (27%), N-H Black (26%), and API (22%) women. Notably, API women aged 35–39 had the highest first-birth rates in 2012 (19.7 per 1,000 women aged 35–39) followed by N-H White (11.9), Hispanic (7.6), and N-H Black (7.3) women.

Among women aged 40–44, the increase in first-birth rates from 1990 to 2012 was largest for N-H Black (171%) and N-H White (130%) women. Of all race and Hispanic origin groups, API women at age 40–44 had the highest first-birth rates (4.3 per 1,000 women aged 40–44) in 2012, followed by N-H White (2.3), N-H Black (1.9), and Hispanic (1.8). In light of weathering, the increasing average maternal age across racial/ethnic groups may imply a greater amount of accumulated chronic stress burden at the time of first birth for some populations than when the first childbirth comes earlier.

Therefore, it is necessary to investigate if weathering applies to other racial/ethnic groups of women than N-H Black women through testing the interactive relationship

between maternal age and chronic stress for each racial/ethnic group. This research could help elaborate the chronic stress mechanisms, identify at-risk age groups with high rates of PTB within each race/ethnicity, and design health policies and programs to narrow the racial/ethnic gaps in PTB by reflecting the demographic shift in the U.S. childbearing population.

Specific Aims and Hypotheses

The purpose of this study is to examine the effect of chronic stress before and during pregnancy on PTB across maternal age among four racial/ethnic groups in the U.S.: N-H White, N-H Black, Hispanic, and Asian women. The study has three specific aims.

Aim 1: To identify the known chronic stressors affecting birth outcomes before and during pregnancy experienced by four racial/ethnic groups.

Aim 2: To assess underlying factor structures and obtain initial psychometric information on chronic stress before and during pregnancy for four racial/ethnic groups.

H1: An underlying factor structure of chronic stress before and during pregnancy differs by race/ethnicity.

Aim 3: To explore the moderating effects of race/ethnicity and maternal age on the relationship between chronic stress and PTB.

H1: The effect of chronic stress on PTB is different according to both race/ethnicity and maternal age.

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CHAPTER 2: PAPER 1

Chronic Stress Measures Before and During Pregnancy as Predictors for Adverse Birth Outcomes among Racial/Ethnic Groups in the U.S.

*Sangmi Kim, MPH, RN, sangmik@nursing.upenn.edu

**Eun-Ok Im, PhD, MPH, RN, CNS, FAAN, eun-ok.im@duke.edu

*Jianghong Liu, PhD, RN, FAAN, jhliu@nursing.upenn.edu

*Connie Ulrich, PhD, RN, FAAN, culrich@nursing.upenn.edu

Author Note

*University of Pennsylvania School of Nursing, Claire M. Fagin Hall
418 Curie Blvd., Philadelphia, PA 19104
**Duke University School of Nursing, 307 Trent Drive, Durham, NC 27710

Address for Correspondence:

Sangmi Kim, MPH, RN
Email: sangmik@nursing.upenn.edu / Phone: 484-821-7337

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Abstract

Objective: This study aimed to identify studies examining the association between chronic stress and adverse birth outcomes among racial/ethnic groups in the U.S., and to determine how chronic stress was operationalized in these studies.

Methods: Peer-reviewed articles investigating chronic stress as a contributing factor to the racial/ethnic disparities in adverse birth outcomes in the U.S. were identified through systematic searches of MEDLINE, CINAHL, PsycINFO, EMBASE, Cochrane Database, and Google Scholar. Articles published between 1990 and 2015 were evaluated to determine domain(s) of chronic stress, features of chronic stress measurement (e.g., comprehensive or cumulative), and chronic stress-birth outcome relationship.

Results: 95 chronic stress measures across 17 studies were evaluated and sorted into four stress domains. 45 of them fell under external stressors (e.g., low socioeconomic status), followed by perceived stress (e.g., racism; n = 28) and buffers (e.g., social support; n = 11) and enhancers of stress (e.g., psychological distress; n = 11). Ten studies assessed chronic stress derived from at least two domains. Only four studies measured chronic stress in cumulative fashions. Less attention was paid to unique sources of chronic stress among racial/ethnic groups. Varying ways of assessing chronic stress resulted in mixed findings of the chronic stress-birth outcome relationship.

Conclusions: Developing race/ethnicity-specific, cumulative measures of chronic stress across multiple stress domains could increase the quality of chronic stress measures. It would contribute to producing more accurate data on chronic stress mechanisms of poor

birth outcomes among racial/ethnic minority groups, through which culturally sensitive prevention strategies could be developed.

Keywords: Chronic stress, stress measurement, race/ethnicity, birth outcomes, review

Significance

✓ What is already known on this subject?

Chronic stress over the life course has been suggested to explain the persistent racial/ethnic gaps in adverse birth outcomes in the U.S. Nevertheless, evidence on the relationship between chronic stress and adverse birth outcomes is inconsistent because of a wide range of operational definitions of chronic stress in the literature.

✓ What this study adds?

Existing chronic stress measures predominantly assess external stressors, overlooking other dimensions of chronic stress (e.g., buffers, enhancers, and perceived stress). Individual stressors, independent of other stressors, tend to reflect one's entire chronic stress before and during pregnancy. Potential racial/ethnic differences in chronic stress experience are rarely incorporated in its measures.

Introduction

Despite numerous efforts for decades, racial/ethnic gaps in adverse birth outcomes, such as preterm birth (PTB; < 37 weeks' gestation) and low birthweight (LBW; < 2,500 g birthweight) persist in the U.S. Non-Hispanic (N-H) Black (16.5%) and Hispanic women (11.6%), respectively, are approximately 60% and 10% more likely to experience PTB than N-H White women (10.3%; Healthy People 2020, 2015). Also, the rate of LBW among N-H Black women (13.2%) doubles the rate among N-H White women (7.0%; U.S. Department of Health and Human Services, 2013).

The reasons for such racial/ethnic disparities are unclear. Well-established biomedical, behavioral, and sociodemographic risk factors have been estimated to explain only about half of the incidence of PTB or LBW, which prompted a re-examination of conventional explanatory models (American College of Obstetricians and Gynecologists Committee on Health Care for Underserved Women, 2006; American Public Health Association, 2006). Stress has drawn a great deal of attention to account for the remained racial/ethnic differences after controlling for the known maternal characteristics. Chronic stress in particular has been acknowledged to be a robust predictor of adverse birth outcomes through neuroendocrine, inflammatory/immune, vascular, or behavioral pathways (Borders, Grobman, Amsden, & Holl, 2007; Dunkel Schetter, 2011; Dunkel Schetter & Glynn, 2010; McDonald, Kingston, Bayrampour, Dolan, & Tough, 2014). Strutz et al. (2014) documented that preconception chronic stressors, but not acute stressors had a statistically significant inverse relation with birthweight among both first and second births; chronic stressors partially attenuated the association between maternal race/ethnicity and birthweight. Also, Geronimus argued that chronic stress and high

coping efforts (e.g., cognitive and emotional efforts to deal with long-term stress) among Black women may accelerate their biological aging; so Black women experience a steeper increase in adverse birth risk with advancing maternal age than do their White counterparts, resulting in wider gaps in the adverse birth risk among older women (Geronimus, 1992; Geronimus, 1996).

Nevertheless, stressful life events, such as having a sick and hospitalized family member, moving to a new address, separation or divorce, or homelessness have by far been predominantly used in the literature because they are relatively easy and simple to measure (Latendresse, 2009; Lu & Chen, 2004). For example, Dole et al. (2004) summed the 39 life events from the Life Experiences Survey (Sarason, Johnson, & Siegel, 1978) that the woman indicated she had experienced since she got pregnant and considered to have had a negative impact on her life (cut-points of 0-2, 3-5, 6-8, and >8 events). Counting stressful life events often leads to insignificant study findings, which is attributable to overlooking the complex nature of individual stress experiences (Latendresse, 2009). Although stressful life events have a significant influence on adverse birth outcomes (Lu & Chen, 2004; Witt, Litzelman, Cheng, Wakeel, & Barker, 2014), this dramatic but less frequent stress may underestimate the extent of stress experienced by vulnerable populations, including racial/ethnic minorities and people at a low socioeconomic status (SES; Turner, 2010). For this reason, chronic stress, more pervasive in the lives of women of color, may better explain the racial/ethnic differences in adverse birth outcomes (Lu & Chen, 2004). Indeed, many studies using other stress measures have called for consideration of chronic stress in future research to shed light

on mechanisms of the excessive risks for adverse birth outcomes among racial/ethnic minority women (Dunkel Schetter & Glynn, 2010; Lu & Chen, 2004).

A major obstacle to conducting research on the contribution of chronic stress to the racial/ethnic disparities in adverse birth outcomes is inconsistently operationalized chronic stress. A standardized, comprehensive measure of chronic stress is lacking in much of the research (Latendresse, 2009). This issue, however, is not limited to chronic stress; it extends to stress measures in general (Dunkel Schetter & Glynn, 2010; Littleton, Bye, Buck, & Amacker, 2010; Witt et al., 2014). Different conceptualizations of stress across the literature have led to mixed findings on the relationship between stress and adverse birth outcomes (Littleton et al., 2010; Woods-Giscombe & Lobel, 2008). Thus, understanding how chronic stress is operationalized is essential to thoroughly investigating the pathways by which chronic stress accounts for adverse birth outcomes among racial/ethnic minority women (Witt et al., 2014).

This literature review was guided by four stress domains suggested by Dole et al. (2003): that is, external stressors (e.g., stressful life events), buffers of stress (e.g., social support), enhancers of stress (e.g., depression and pregnancy-related anxiety), and perceived stress (e.g., perceived racial discrimination). Given the complexity of the nature of chronic stress, these four domains cover multiple dimensions of chronic stress experienced by racial/ethnic groups of women. Woods-Giscombe and Lobel (2008) emphasized the importance of stress measures being as comprehensive as possible in its conceptualization and operationalization to ensure that the effect of stress on health outcomes is valid and complete.

Therefore, the purpose of this review is to 1) identify and analyze studies investigating chronic stress as a risk factor for adverse birth outcomes among racial/ethnic groups of women in the U.S.; and 2) understand how chronic stress has been operationalized across the four stress domains in these studies. The current state of knowledge about chronic stress measurement and its limitations in the context of birth outcomes can provide useful information to researchers, clinicians, and policymakers in the field of maternal and child health (MCH) to narrow the racial/ethnic gaps in adverse birth outcomes through accurate assessment of and targeted intervention with chronic stress experienced by racial/ethnic minority women in the U.S.

Methods

Initial Search Strategy

Relevant literature (n =166) was identified through a systematic search of the PubMed, CINAHL, PsycINFO, EMBASE, Cochrane Database, and Google Scholar databases. Articles published between 1990 and 2015 were initially selected based on the appearance of fourteen keywords in the article title or abstract: "chronic stress," "cumulative stress," "prepregnancy," "preconception," "pregnancy," "Black," "Hispanic," "Asian," "ethnic minority," "adverse birth outcomes," "birthweight," "gestational age," "preterm," and "infant mortality."

Screening and Article Selection

A two-step process was used to select articles. First, the articles were sorted by author(s) and screened by their titles and abstracts. Articles (n = 61) were marked when measuring chronic stress before and during pregnancy as a risk factor for adverse birth outcomes for future review. Second, the full texts of all marked articles were examined.

The references of retrieved articles were reviewed for additional publications that were not captured in the original search, and these articles (n = 21) were then retrieved as well.

Articles included in this review were those 1) published in English; 2) published between 1990 and 2015 in a peer-reviewed journal; 3) human research; 4) explicitly measuring chronic stress among women in the U.S. before or during pregnancy 5) examining chronic stress as an independent variable and adverse birth outcomes as an outcome variable; and 6) having access to a full text article.

Data Collection for Selected Articles

The collected information through the full-text articles included 1) the type of study (e.g., data-based, descriptive, or review); 2) race/ethnicity studied; 3) the instrument(s) or proxy variable(s) of chronic stress; 4) whether the instruments used were reliable, if applicable; 5) the domains of chronic stress based on the question or measure used in the study; 6) how the chronic stressors were tested (e.g., individually or cumulatively); 7) the period of exposure to chronic stressors (e.g., before or during pregnancy); 8) the time chronic stress was measured or surveyed (e.g., before/during pregnancy or after delivery); 9) birth outcomes studied; and 10) the magnitude of chronic stress-birth outcome relationships. Next, the frequency of identified chronic stress measures was evaluated by the stress domain in the reviewed articles. This study was exempt from IRB approval.

Results

The search identified 166 articles (Figure 1). After reviewing titles and abstracts, a total of 82 articles met initial inclusion criteria including 21 articles additionally retrieved from the references of the 61 selected articles. After reading each full article, 17

met all inclusion criteria. Individual chronic stress measures were counted and added up to a total of 95 items across 17 studies. The chronic stress measures of "work and living environment" (Latendresse, 2009) and "lack of resources" (Hobel, Goldstein, & Barrett, 2008) were excluded due to their broad scope and ambiguity in meaning.

[Insert Figure 1]

Table 1 illustrates characteristics of the reviewed studies. Eight studies (47.1%) reviewed the existing articles and documented chronic stress pathways to adverse birth outcomes. Six studies (35.3%) did not specify racial/ethnic groups examined; only two studies (11.8%) specifically targeted Black women as study subjects. 95 chronic stress measures were derived from instruments (34.7%), proxy variables in the collected data (31.6%), and concepts suggested in the review papers (33.7%). Approximately a half of chronic stress measures (47.3%) were concentrated in the domain of external stressors, followed by perceived stress (29.5%). Also, 23.5% of the studies employed chronic stress measures independently. 40.0% and 27.4% of the chronic stress measures were collected both before and during pregnancy, and retrospectively after delivery, respectively. Most of the studies examined PTB/gestational age (46.2%) or LBW/birth weight (34.6%) as adverse birth outcomes (Appendix A). [Insert Table 1]

Operationalization of Chronic Stress by Domain

Table 2 shows contents and frequencies of the operationalized chronic stress by the stress domain. External stressors are categorized into twelve stress areas, including low SES, early life stress, neighborhood stress, and others. Buffers of stress include five categories, including social support. Enhancers of stress include two groups,

predominantly represented by psychological distress. Lastly, perceived stress is comprised of four stress areas, including racism and role strain. [Insert Table 2]

External stressors

Of the 45 retrieved measures, 35.6% operationalized low SES as chronic stress during the prenatal period, followed by early life stress (11.1%), neighborhood stress (11.1%), domestic violence and/or lasting fear (6.7%), stressful life events (6.7%), daily chronic stressors (6.7%), acculturation stress (6.7%), interpersonal stress (4.4%), parenting stress (4.4%), pregnancy stress (2.2%), physically stressful job (2.2%), and having a child with chronic illness in the home (2.2%; Table 2).

Low SES was represented by financial stress, including Financial Stress Index (Dunkel Schetter et al., 2013), low household income (Guendelman, Lang Kosa, Pearl, Graham, & Kharrazi, 2008), and poverty (Latendresse, 2009; Rich-Edwards & Grizzard, 2005). Also, other indicators of low SES included home crowdedness (Borders et al., 2007; Dunkel Schetter & Tanner, 2012); low educational attainment (Guendelman et al., 2008; Strutz et al., 2014); unemployment (Borders et al., 2007; Dunkel Schetter & Tanner, 2012); difficulties obtaining medical care (Borders et al., 2007; Strutz et al., 2014); hardships in the home environment (Borders et al., 2007); and food insecurity (Borders et al., 2007). Only one study mentioned low SES in general as chronic stress (Dunkel Schetter, 2011).

For early life stress, only one study adopted five measures of childhood adversity to partially capture chronic stress: living without either biological parent, low parent educational attainment, low parent income, parent not being able to pay bills, and parent receiving public assistance (Strutz et al., 2014). Although Rich-Edwards et al. (2001)

took a life course approach by using experience of racial discrimination during childhood and experience of violence and lasting fear of physical/sexual attack during childhood and adolescence as early life stress. However, for the purpose of this analysis, they were categorized into racism and domestic violence and/or lasting fear, respectively, because sources of chronic stress were very specific, and these chronic stressors were assessed across the lifespan from childhood to during pregnancy.

For neighborhood stress, five measures of neighborhood stress tapped different dimensions of living environment deemed chronically stressful, including physical (e.g., neighborhood noise; Stapleton et al., 2015), interpersonal (e.g., familiarity/problem with neighbors; Stapleton et al., 2015), and socioeconomic stressors (e.g., high neighborhood poverty, high neighborhood unemployment, and low neighborhood household education; Strutz et al., 2014).

Although relatively less used in the reviewed studies (≤ 10%), domestic violence and/or lasting fear (Dunkel Schetter et al., 2013; Latendresse, 2009; Rich-Edwards et al., 2001), stressful life events (Borders et al., 2007; Dunkel Schetter et al., 2013; Wilson, Dyer, Latendresse, Wong, & Baksh, 2015), daily chronic stressors (Chen, Grobman, Gollan, & Borders, 2011; Hobel et al., 2008), acculturation stress (Hobel et al., 2008; Strutz et al., 2014), interpersonal stress (Stapleton et al., 2015), parenting stress (Dunkel Schetter et al., 2013; Stapleton et al., 2015), pregnancy stress (Dunkel Schetter et al., 2013), physically stressful job (Guendelman et al., 2008), and child with chronic illness in the home (Borders et al., 2007) were also operationalized definitions of chronic stress before and during pregnancy. Of note, domestic violence was reported either not specifying particular types of violence (e.g., physical, sexual, emotional, or verbal abuse;

Latendresse, 2009) or focusing on physical/sexual assault (Dunkel Schetter et al., 2013; Rich-Edwards et al., 2001). Notably, Rich-Edwards et al. (2001) assessed not only the incident of physical or sexual attack but also lasting fear of the abuse.

Buffers and enhancers of stress

As to buffers of stress, social support (45.4%) was the most widely used operationalized definition, either its sources or means (Borders et al., 2007; Guendelman et al., 2008; Stapleton et al., 2015), followed by coping strategies (27.3%; Borders et al., 2007; Rich-Edwards et al., 2001), personal coping resources, such as state hope (9.1%; Borders et al., 2007), adequate sleep (≥ 6 hours/night; 9.1%; Guendelman et al., 2008), and general coping mechanisms (9.1%; Hobel et al., 2008). Insufficient buffers of stress (e.g., poor social support, poor coping skills, or short hours of sleep at night) were operated as chronic stressors as demonstrated in some studies (Borders et al., 2007; Guendelman et al., 2008).

Additionally, enhancers of stress was predominantly represented by psychological distress (90.9%), including depression (Borders et al., 2007; Hobel et al., 2008; Latendresse, 2009), anxiety (Hobel et al., 2008; Latendresse, 2009), pregnancy-related anxiety (Hobel et al., 2008), anger (e.g., strong anger in second trimester; Guendelman et al., 2008), distress (Hobel et al., 2008), negative affect (Hobel et al., 2008), and externalized and internalized emotional reactions to stressors (Rich-Edwards et al., 2001).

Perceived stress

Chronic stress measures as "perceived stress" (n = 28) were the second most adopted in the reviewed literature after external stressors (n = 45). It encompassed racism (Dominguez, 2008; Dunkel Schetter, 2011; Dunkel Schetter et al., 2013; Dunkel Schetter

& Tanner, 2012; Guendelman et al., 2008; Hoffman & Hatch, 1996; Latendresse, 2009; Rich-Edwards & Grizzard, 2005; Rich-Edwards et al., 2001), role strain (e.g., work, household, marital, and general strain; Dunkel Schetter, 2011; Guendelman et al., 2008; Hobel et al., 2008; Hoffman & Hatch, 1996), lack of neighborhood safety (Borders et al., 2007; Rich-Edwards & Grizzard, 2005; Stapleton et al., 2015), and general perceived stress (Borders et al., 2007; Dunkel Schetter et al., 2013; Ghosh, Wilhelm, Dunkel-Schetter, Lombardi, & Ritz, 2010; Guendelman et al., 2008; Latendresse, 2009; Wadhwa, Sandman, Porto, Dunkel-Schetter, & Garite, 1993). General perceived stress was mostly assessed with the Perceived Stress Scale (Dunkel Schetter et al., 2013; Ghosh et al., 2010; Guendelman et al., 2008; Latendresse, 2009; Wadhwa et al., 1993).

It is not clear whether racism falls under the category of perceived stress since only two out of nine studies that operationalized racism as chronic stress specifically stated racism as being "perceived" (Dunkel Schetter, 2011; Dunkel Schetter et al., 2013). Racism refers to "beliefs, attitudes, institutional arrangements, and acts that tend to denigrate individuals or groups because of phenotypic characteristics or ethnic group affiliation" (Clark, Anderson, Clark, & Williams, 1999, p. 805). Perceived racism, on the other hand, is defined as the subjective experience of prejudice (i.e., differential assumptions about the abilities, motives, and intents of others by race) or discrimination (i.e., differential actions toward others by race), which is not necessarily limited to experiences objectively viewed as racism (Clark et al., 1999; Jones, 2001). Although subjective stress is distinguishable from objective stress, racism was sorted, either specified as perceived or not, into the domain of perceived stress by adopting the aforementioned definition of perceived racism that incorporates both subjective and

objective experiences as a source of stress. Varying terms indicative of racism were used among the studies depending on the scope of a racist experience. This included: perceived racism and discrimination (Dunkel Schetter, 2011; Dunkel Schetter et al., 2013); racism (Dunkel Schetter & Tanner, 2012; Rich-Edwards & Grizzard, 2005); individual (interpersonal) and/or institutional racism (Dominguez, 2008; Hoffman & Hatch, 1996); unfair treatment because of race/ethnicity (Guendelman et al., 2008); and discrimination (Latendresse, 2009; Rich-Edwards et al., 2001).

Measurement Characteristics

Chronic stress measures within 17 reviewed articles were further evaluated for their degree of comprehensiveness. First, over a half of the studies (n = 10) assessed chronic stress before or during pregnancy from at least two domains: four studies with all four domains (Borders et al., 2007; Guendelman et al., 2008; Hobel et al., 2008; Rich-Edwards et al., 2001); three studies with three domains in the absence of either buffers (Latendresse, 2009) or enhancers of stress (Dunkel Schetter et al., 2013; Stapleton et al., 2015); and three studies with two domains of external stressors and perceived stress (Dunkel Schetter, 2011; Dunkel Schetter & Tanner, 2012; Rich-Edwards & Grizzard, 2005). In contrast, seven studies employed chronic stress measures from a single domain either from external stressors (Chen et al., 2011; Strutz et al., 2014; Wilson et al., 2015) or perceived stress (Dominguez, Dunkel-Schetter, Glynn, Hobel, & Sandman, 2008; Ghosh et al., 2010; Hoffman & Hatch, 1996; Wadhwa et al., 1993).

Next, only four studies measured chronic stress before and during pregnancy in cumulative fashions. For example, Wilson et al. (2015) counted the number of categories of stressful life events (e.g., partner, emotional, traumatic, or financial stress) that women

experienced during the 12 months before pregnancy to create a chronic stress score for individuals ranging from zero (no response to all questions in all of the stress categories) to four (at least one yes in all four categories). Similarly, Guendelman et al. (2008) counted and categorized the number of experienced chronic stressors into none, ≥ 1, ≥ 2, or ≥ 3 of the seven stressors. Another traditional way of quantifying the degree of chronic stress, as adopted by Stapleton et al. (2015), was to average ratings for each area of chronic stress (e.g., neighborhood, family, current partner, and co-parenting with baby's father) ranging from one (exceptionally positive conditions; low stress) to five (exceptionally negative conditions; high stress) into a single index of chronic stress within each domain. In this study, however, overall domain ratings were not mathematical averages of the domain ratings but a summary judgment of chronic stress in each domain made by the interviewer who also considered all relevant information obtained during the interview. Finally, Strutz et al. (2014) modeled twelve chronic stressors as an unobserved or latent factor of chronic stress in confirmatory factor analysis (CFA) and generated a factor score for individuals. The CFA model for chronic stress fit well the subsamples of first and second births to White, Mexican-origin Latina, other origin-Latina, and Black women.

Effect of Chronic Stress on Adverse Birth Outcomes

Six data-based studies reported the magnitude of chronic stress-birth outcome relationships (Borders et al., 2007; Ghosh et al., 2010; Guendelman et al., 2008; Strutz et al., 2014; Wadhwa et al., 1993; Wilson et al., 2015). In these studies, adverse birth outcomes examined were limited only to LBW or birthweight (66.7%; Borders et al., 2007; Strutz et al., 2014; Wadhwa et al., 1993; Wilson et al., 2015), PTB or gestational

age (50%; Ghosh et al, 2010; Guendelman et al., 2008; Wadhwa et al., 1993), and 1- and 5- minute Apgar scores (16.7%; Wadhwa et al., 1993).

Two studies allowed to investigate how chronic stress mediated the effect of race/ethnicity on adverse birth outcomes (Strutz et al., 2014; Wilson et al., 2015); and one study treated race/ethnicity as a moderator of the chronic stress-birth outcome relationships (Ghosh et al., 2010). The remaining studies documented the composition of racial/ethnic groups of the study populations, but race/ethnicity was not their interest in the study such that only the effect of chronic stress on adverse birth outcomes was presented, either not incorporating race/ethnicity in the statistical models at all (Borders et al., 2007; Wadhwa et al., 1993) or controlling for race/ethnicity (Guendelman et al., 2008).

The research findings regarding the effect of chronic stress on adverse birth outcomes were conflicting or inconsistent across the studies. For instance, after controlling for race/ethnicity, Ghosh et al. (2010) found 46% increase in PTB risk among women with high chronic stress while Guendelman et al. (2008) did not find any significant effect of chronic stress on PTB. Also, an effect size of chronic stress on birthweight differed between the studies. Strutz et al. (2014) documented a decrease in birthweight by 139 grams with one-unit increase in chronic stress whereas Wilson et al. (2015) reported the decrease only by 15.6 grams when other risk factors, including race/ethnicity, were held constant. Even, Wadhwa et al. (1993) did not observe a significant association of chronic stress with birthweight even before controlling for covariates.

Further, despite little evidence, inconsistencies were noted in to what extent chronic stress mediated the effect of race/ethnicity on adverse birth outcomes. Strutz et al. (2014) found that chronic stress partially accounted for lower birthweight among N-H Black and Mexican-origin Hispanic than among N-H White women; and chronic stress totally explained the birthweight gap between other-origin Hispanic and N-H White women. On the other hand, Wilson et al. (2015) showed an insignificant effect of racial/ethnic minority status (e.g., Hispanic or non-White) on birthweight when chronic stress was incorporated in the model with other covariates altogether.

Discussion

This study identified and synthesized the literature on the contribution of chronic stress before and during pregnancy to adverse birth risk (e.g., LBW and PTB) among women in the U.S., particularly racial/ethnic minority groups of women. Chronic stress was inconsistently operationalized across the studies, most of which reflected external stressors (47.3%) that were objectively measurable. Although four domains of chronic stress (i.e., external stressors, buffers of stress, enhancers of stress, and perceived stress) are distinct yet intertwined, only 23.5% of the studies measured and aggregated chronic stressors across multiple domains to develop a comprehensive and cumulative matrix of chronic stress. The varying operational definitions of chronic stress among the studies led to mixed findings of the significance and magnitude of chronic stress-birth outcome relationships as well as to what extent chronic stress explained the racial/ethnic differentials in adverse birth outcomes.

Based on this literature review, three suggestions can be made for research in this field. First, identifying or developing optimal measures of maternal chronic stress is

imperative. Currently, extant research does not allow determination of the best or most reliable and valid indicators that capture chronic stress for use in the research or clinical setting (Chen et al., 2011). Indeed, Dole et al. (2003) stated that there are a wide variety of psychosocial domains and associated instruments, with no "gold standard" (p. 22). This is corroborated by the current study that identified a wide variation in how chronic stress was operationalized, including categories and even more subcategories of chronic stressors within each of the stress domain.

Additionally, over half of the nine empirical studies (e.g., data-based or descriptive) used each chronic stress measure independently. As a single measure reflective of chronic stress, racism was the most widely used or suggested (n = 9) followed by perceived stress (n = 5), financial stress (n = 4), and work strain (n = 4). However, considering a multi-faceted, complicated nature of chronic stress, evaluating only a single aspect of chronic stress not only is at odds with the premise that stressors co-occur, accumulate, and persist (Dunkel Schetter et al., 2013) but also captures a limited portion of the chronic stress process (Witt et al., 2014).

With an absence of no complete single measure of chronic stress, an alternative way to best capture it would be to employ cumulative measures of chronic stress through a composite index or latent factor consolidating across comprehensive chronic stressors from multiple domains (e.g., external stressors, buffers of stress, enhancers of stress, and perceived stress). Composite factors of chronic stress have two advantages over individual and independent measures. First, the measurement of chronic stress is conceptually and empirically improved by combining the common variance of related individual measures. Second, summarizing multiple chronic stressors into composite

factors eliminates the risk of multicollinearity in multivariate analysis that may result from highly correlated or dependent chronic stressors (Wadhwa et al., 1993).

Of importance, assessment of individual chronic stress should not overlook one's neighborhood-related chronic stress experiences. For people who endure unfavorable neighborhood conditions everyday (e.g., impoverished or unsafe neighborhoods), neighborhood or environmental stressors may be a reliable indicator of chronic stress that is not fully captured by individual-level stressors. This is because neighborhood conditions change more slowly than individual conditions, and in turn exert a more constant set of influences on people's lives, experiences, and health outcomes (Rauh, Andrews, & Garfinkel, 2001). Besides, neighborhood characteristics have a significant impact on health outcomes, above and beyond the effect of individual-level risk factors (Culhane & Elo, 2005).

Further, chronic stress measurement should take a life-course approach by considering history of one's chronic stress experiences, for example, not only during but also before pregnancy. Only 18.9% of the chronic stress measures (n = 18) in this study spanned both periods; 63.2% of them (n = 60) captured chronic stress exposed either before or during pregnancy (31.6% and 31.6%). Developing aggregate measures of individual and environmental chronic stressors possibly over the life course may be a more valid representation of the way chronic stress operates, and accordingly, increase the quality and predictive power to detect the effect of chronic stress on health outcomes (Dunkel Schetter & Glynn, 2010; Troxel, Matthews, Bromberger, & Sutton-Tyrrell, 2003).

Second, potential differences in chronic stress experience among racial/ethnic groups are worth exploring since lived experience of each of these populations, whose identity is constructed at the intersection of race, gender, and class, is closely linked to their unique cultural, social, regional, and historical contexts (Jackson, Phillips, Hogue, & Curry-Owens, 2001). Notably, researchers have attempted to investigate identity stressors connected to race and gender—gendered racism—as a unique source of stress among Black women (Jackson, Hogue, & Phillips, 2005; Jackson et al., 2001; Woods-Giscombe & Lobel, 2008). For example, Black women's nurturing load becomes potentially more burdensome if they have to go outside of their communities to meet the needs of their children due to the insufficient resources/services in Black communities and feel responsibilities to protect their children or Black children as a whole from racism (Jackson et al., 2005; Jackson et al., 2001). Black women's perceived obligation to be strong and independent, known as the superwoman schema, is also regarded as a unique feature of their stress experience (Woods-Giscombé, 2010). Nevertheless, the current chronic stress measures rarely reflected stress experiences specific to racial/ethnic groups. Six reviewed articles (35.3%) did not specify racial/ethnic groups of women studied (Chen et al., 2011; Dunkel Schetter, 2011; Dunkel Schetter & Tanner, 2012; Hobel et al., 2008; Hoffman & Hatch, 1996; Latendresse, 2009). Three data-based studies (17.6%) did report the racial/ethnic background of study subjects, but race/ethnicity was not taken into account in estimating the relationship between chronic stress and adverse birth outcomes (Borders et al., 2007; Guendelman et al., 2008; Wadhwa et al., 1993). Instead, they targeted general U.S. populations or particularly those in disadvantaged positions (e.g., low-income women) with an assumption that chronic stress experience is

universal across the board. Two studies (11.8%) documented chronic stressors among Black women, including poverty, lack of neighborhood safety, and interpersonal and institutional racism (Dominguez et al., 2008; Rich-Edwards & Grizzard, 2005). These sources of chronic stress, however, are not limited to Black populations despite their more frequent and concentrated exposure to such unfavorable life conditions. Also, only one of three studies that investigated Hispanic women encompassed acculturation stress, represented by English as a second language and foreign-born status (Strutz et al., 2014). The lacked interest of the existing research in race/ethnicity-specific chronic stress exposure and appraisal indicates decontextualized and in turn less accurate stress measurement by obscuring each racial/ethnic group's lived experience as a community. This would impede revealing chronic stress mechanisms underlying the racial/ethnic inequalities in adverse birth outcomes.

Third, more empirical studies are called for to examine the impact of chronic stress on various adverse birth outcomes beyond LBW and PTB among diverse racial/ethnic minority groups of women. In this study, only six articles were data-based, which quantified the effect of chronic stress on birth outcomes; eight studies were literature review about what constituted chronic stress and through what pathways it contributed to poor birth outcomes. Subsequently, a third of chronic stressors identified (33.7%) were just concepts that future research can utilize. Also, as mentioned earlier, research findings in the current literature do not converge to answer if and to what extent chronic stress explains adverse birth outcomes or their racial/ethnic gaps. Ample empirical evidence in this area of research will inform what sources of chronic stress

need to be targeted for interventions to reduce specific adverse birth outcomes most effectively in particular racial/ethnic communities.

Several limitations should be considered when interpreting the results. Although a comprehensive literature search was conducted to identify articles for inclusion, some relevant articles may have been missed. Nevertheless, the breadth of identified chronic stress measures across the four domains, including external stressors, buffers and enhancers of stress, and perceived stress makes the possible impact of overlooked studies minimal. For instance, although not being specified in the reviewed articles, such a stressful experience as unwanted pregnancy may lead to unfavorable birth outcomes not because of the event per se but because of underlying chronic stressors, such as low SES and lack of social support. Also, studies conducted outside of the U.S were excluded. Different components and patterns of chronic stress may have been discovered by incorporating these studies. As mentioned above, however, chronic stress experience needs to be understood in the contexts relevant to race/ethnicity, gender, migration, and geographic locations. Thus, the study's inclusion criteria are justifiable given chronic stress as the subject of investigation. Lastly, a broad range of covariates or confounders in the data-based studies reviewed may have contributed to the inconsistent results regarding if or to what extent chronic stress influences adverse birth outcomes. Even treating race/ethnicity as a covariate or confounder made it difficult to compare the chronic stress-birth outcome association among racial/ethnic groups.

Chronic stress holds a great potential to cast light on causal mechanisms of the persistent racial/ethnic inequalities in adverse birth outcomes in the U.S. Nevertheless, varying definitions of chronic stress hinder our understanding of the pernicious influence

of chronic stress on birth outcomes by producing inconsistent study findings. To advance our knowledge regarding the chronic stress-birth outcome relationships among racial/ethnic minority women, it is suggested to develop race/ethnicity-specific, composite measures of chronic stress experienced before and during pregnancy that capture its multiple dimensions, instead of independent, universal measures of chronic stress. Such composite matrices of chronic stress unique to each racial/ethnic group could lay the foundation for researchers, clinicians, and policymakers working in the MCH field to develop culturally sensitive and targeted interventions in order to address the unequal distributions of adverse birth risk in racial/ethnic minority communities through generating reliable and valid data.

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Figure 1 top

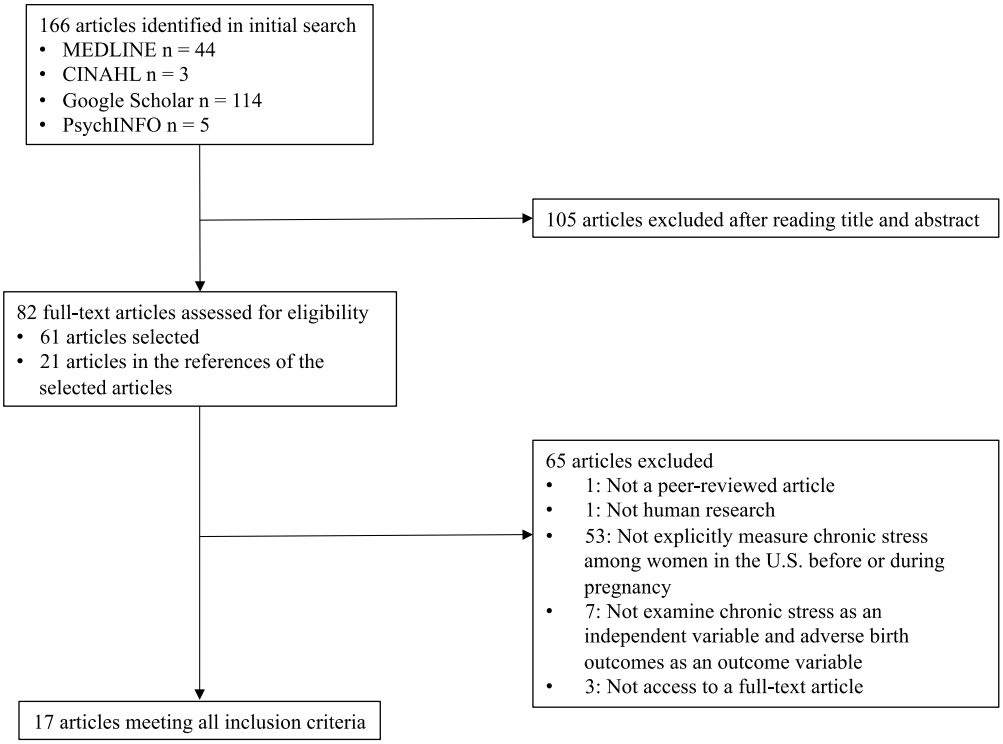
166 articles identified in initial search
• MEDLINE n = 44
• CINAHL n = 3
• Google Scholar n = 114
• PsychINFO n = 5
105 articles excluded after reading title and abstract
82 full-text articles assessed for eligibility
• 61 articles selected
• 21 articles in the references of the selected articles
65 articles excluded
• 1: Not a peer-reviewed article
• 1: Not human research
• 53: Not explicitly measure chronic stress among women in the U.S. before or during pregnancy
• 7: Not examine chronic stress as an independent variable and adverse birth outcomes as an outcome variable
• 3: Not access to a full-text article
17 articles meeting all inclusion criteria

Figure Captions

Figure 1. Flow diagram of the systematic literature search and selection process

Table 1.
Characteristics of Studies Examining Chronic Stress Before and During Pregnancy in Relation to Adverse Birth Outcomes among Racial/Ethnic Groups in the U.S.

Characteristic	N	%
Type of Studies (n = 17)		
Data-based	6	35.3
Descriptive[a]	3	17.6
Review	8	47.1
Race/Ethnicity (n = 17)		
Not Specified	6	35.3
Not Interested	3	17.6
Only Black	2	11.8
White, Black, and Hispanic	3	17.6
White, Black, Hispanic, and Asian (or other)	2	11.8
White and non-White or Hispanic and non-Hispanic	1	5.9
Chronic Stress Measures (n = 95)[b]		
Instruments	33	34.7
Proxy Variables in the Data	30	31.6
Concepts Suggested	32	33.7
Chronic Stress Domains (n = 95)		
External Stressors	45	47.3
Buffers of Stress	11	11.6
Enhancers of Stress	11	11.6
Perceived Stress	28	29.5
Measurement Method (n =17)		
Individual	4	23.5

Cumulative	4	23.5
Both	1	5.9
Not Applicable	8	47.1
Period of Stress Exposure (n = 95)		
Before Pregnancy	30	31.6
During Pregnancy	30	31.6
Both Periods	18	18.9
Not Specified	17	17.9
Time Measured (n = 95)		
Before Pregnancy	19	20.0
During Pregnancy	19	20.0
Within 6 Months of Delivery	26	27.4
Not Specified	31	32.6
Birth Outcomes (n = 26)[c]		
Low Birth Weight or Birth Weight	9	34.6
Preterm Birth or Gestational Age	12	46.2
Intrauterine Growth	1	3.8
Infant Mortality	1	3.8
Apgar Score	1	3.8
Not Specified	2	7.7

[a]Studies whose purpose was to describe the ongoing research projects (e.g., sample, study settings, measurement, study process, future analysis plans, and implications) or preliminary findings which did not include the estimated effect of chronic stress on birth outcomes of interest.
[b]The number of all chronic stress measures counted across 17 selected articles.
[c]Multiple birth outcomes were counted if the study examined two or more birth outcomes at the same time.

Table 2.
Contents and Frequencies of Operationalized Chronic Stress as Risk Factor for Adverse Birth Outcomes by Domain

Category	Sub-category	N (% within the domain)
External Stressors		45
Low SES		16 (35.6)
	Financial stress (Dunkel Schetter et al., 2013; Guendelman et al., 2008; Latendresse, 2009; Rich-Edwards & Grizzard, 2005)	4
	Home crowdedness (Borders et al., 2007; Dunkel Schetter & Tanner, 2012; Hobel et al., 2008)	3
	Low educational attainment (Guendelman et al., 2008; Strutz et al., 2014)	2
	Unemployment (Borders et al., 2007; Dunkel Schetter & Tanner, 2012)	2
	Difficulties obtaining medical care (Borders et al., 2007; Strutz et al., 2014)	2
	Hardships in the home environment (Borders et al., 2007)	1
	Food insecurity (Borders et al., 2007)	1
	General (Dunkel Schetter, 2011)	1
Early life stress (Strutz et al., 2014)		5 (11.1)
	Living without either biological parent	1
	Low parent educational attainment	1
	Low parent income	1
	Parent could not pay bills	1
	Parent received public assistance	1
Neighborhood stress		5 (11.1)
	Neighborhood noise (Stapleton et al., 2015)	1
	Familiarity/problem with neighbors (Stapleton et al., 2015)	1

	High neighborhood poverty (Strutz et al., 2014)	1
	High neighborhood unemployment (Strutz et al., 2014)	1
	Low neighborhood household education (Strutz et al., 2014)	1
Domestic violence and/or lasting fear (Dunkel Schetter et al., 2013; Latendresse, 2009; Rich- Edwards et al., 2001)		3 (6.7)
Stressful life events (Borders et al., 2007; Dunkel Schetter et al., 2013; Wilson et al., 2015)		3 (6.7)
Daily chronic stressors		3 (6.7)
	Daily hassles[a] (Chen et al., 2011; Hobel et al., 2008)	2
	Everyday problems[b] (Chen et al., 2011)	1
Acculturation stress		3 (6.7)
	General (Hobel et al., 2008)	1
	English as a second language (Strutz et al., 2014)	1
	Foreign-born (Strutz et al., 2014)	1
Interpersonal stress (Stapleton et al., 2015)		2 (4.4)
	Conflict with family	1
	Conflict with partner	1
Parenting stress (Dunkel Schetter et al., 2013; Stapleton et al., 2015)		2 (4.4)
Pregnancy stress (Dunkel Schetter et al., 2013)		1 (2.2)
Physically stressful job (Guendelman et al., 2008)		1 (2.2)
Child with chronic illness in the home (Borders et al., 2007)		1 (2.2)
Buffers of Stress		11
Social support		5 (45.4)

	General (Borders et al., 2007)	1
	Support from family (Stapleton et al., 2015)	1
	Support from partner (Stapleton et al., 2015)	1
	Emotional support (Guendelman et al., 2008)	1
	Instrumental support (Guendelman et al., 2008)	1
Coping strategies[c]		3 (27.3)
	Problem-focused strategies (e.g., political actions or safety-seeking actions; Rich- Edwards et al., 2001)	1
	Church attendance (Borders et al., 2007)	1
	Community group involvement (Borders et al., 2007)	1
Personal coping resources[d] (Borders et al., 2007)		1 (9.1)
Adequate sleep (Guendelman et al., 2008)		1 (9.1)
General coping mechanisms (Hobel et al., 2008)		1 (9.1)
Enhancers of Stress		11
Psychological distress		10 (90.9)
	Depression (Borders et al., 2007; Hobel et al., 2008; Latendresse, 2009)	3
	Anxiety (Hobel et al., 2008; Latendresse, 2009)	2
	Pregnancy-related anxiety (Hobel et al., 2008)	1
	Anger (Guendelman et al., 2008)	1
	Distress (Hobel et al., 2008)	1
	Negative affect (Hobel et al., 2008)	1
	Externalized and internalized emotional reactions to stressors (Rich- Edwards et al., 2001)	1
Needed treatment for mental health issues		1 (9.1)

(Borders et al., 2007)		
Perceived Stress		28
Racism (Dominguez, 2008; Dunkel Schetter, 2011; Dunkel Schetter et al., 2013; Dunkel Schetter & Tanner, 2012; Guendelman et al., 2008; Hoffman & Hatch, 1996; Latendresse, 2009; Rich-Edwards & Grizzard, 2005; Rich- Edwards et al., 2001)		9 (32.1)
Role strain		9 (32.1)
	Work strain (Guendelman et al., 2008; Hobel et al., 2008; Hoffman & Hatch, 1996)	4[e]
	Household strain	2
	Marital strain (Hobel et al., 2008; Hoffman & Hatch, 1996)	2
	General (Dunkel Schetter, 2011)	1
Perceived stress		7 (25.0)
	Perceived stress (Dunkel Schetter et al., 2013; Ghosh et al., 2010; Guendelman et al., 2008; Latendresse, 2009; Wadhwa et al., 1993)	5
	Perceived economic hardship (Borders et al., 2007)	1
	Self-rated health (Borders et al., 2007)	1
Lack of neighborhood safety (Borders et al., 2007; Rich-Edwards & Grizzard, 2005; Stapleton et al., 2015)		3 (10.8)

[d]Daily hassles are defined as relatively minor events arising out of day-to-day living, such as the everyday concerns of work, caring for others, and commuting between work and home or small, more unexpected events that disrupt daily life, such as arguments with children, unexpected work deadlines, and a malfunctioning oven (Serido, Almeida, & Wethington, 2004).

[b]Everyday problems refer to ongoing, stressful chronic situations that last for a considerable period of time (Burks & Martin, 1985).

[c]Coping strategies consist of behavioral or cognitive attempts to manage specific situational demands which are appraised as taxing or exceeding one's ability to adapt (Lazarus & Folkman, 1984). Coping efforts may be directed at the demands themselves (problem-focused strategies) or at the emotional reactions which often accompany those demands (emotion-focused strategies; Thoits, 1995).

[d]Personal characteristics upon which people may draw when dealing with stressors (e.g., personal control, mastery, or self-esteem; Pearlin & Schooler, 1978).

[e]Guendelman et al. (2008) used two separate instruments (i.e., Siegrist's Effort Reward Imbalance Scale and Karasek's Job Content Questionnaire) to appraise occupational stress among working women.

Appendix A
Characteristics of Measures Used to Assess Chronic Stress and the Strength of Association to Adverse Birth Outcomes

No.	First Author (Year)	Type of Study	Race/ Ethnicity	Stress Measure	Instrument Used	Reliability or Validity	Stress Domain	Individual or Cumulative Measurement	Period of Stress Exposure	Time Measured (Surveyed)	Birth Outcome	Magnitude of the Relationship
1	Borders (2007)	Data-based	Not of interest (low income NHW, NHB, and other racial/ethnic groups of women)	Hardships in the home environment	Home Hardship Scale[a], Women's Employment Study (Sullivan, Turner, & Danziger, 2006)	Not reported	ES	Individual	During pregnancy	Within 6 months of delivery	LBW	OR = 2.0 [0.9-4.3]
				Food insecurity	USDA Household Food Security Scale[b] (Bickel, Nord, Price, Hamilton, & Cook)	Not reported	ES					OR = 3.2 [1.4-7.2]; AOR[c] = 2.6 [1.7, 3.5]
				Child with chronic illness in the home	Do any of the children living in your home have a chronic illness?	NA	ES					OR = 3.4 [1.5-7.9]; AOR = 3.1 [2.3, 4.0]
				Home crowdedness	Number of persons sleeping in the home divided by number of bedroom (more than 2 persons per room = crowdedness)	NA	ES					OR = 2.7 [1.3-5.6]; AOR = 1.8 [0.9, 2.7]
				Unemployed	Are you currently working for pay?	NA	ES					OR = 3.1 [1.2-7.9]; AOR = 3.7 [2.7, 4.7]

Hardship obtaining medical care	Have you had difficulty obtaining medical care in the last year that you felt that you or your family needed?	NA	ES		OR = 1.8 [0.7-1.1]
Stressful life events	Life Events Checklist[d] (Johnson & McCutcheon, 1980)	Direct-Exposure Kappa for each of 16 items = .52-.84 (except for one item of "Caused serious injury/death of another," Kappa = .37); Full-Scale Kappa = .23-.66 (Gray, Litz, Hsu, & Lombardo, 2004)	ES		OR for more than one event = 1.3 [0.5-3.0]
Social support	Social Support Scale[e] (Winston, 1999)	Not reported	BS		OR for poor social support = 2.0 [0.97-4.1]
Coping skills	State Hope Scale (Snyder et al., 1996)	α[f] = .81 (pretest) and .88 (posttest); for the agency subscale, α = .79 (pretest) and .76 (posttest); for the pathways subscale, α = .82 (pretest) and .63 (posttest; Snyder et al., 1996)	BS		OR for poor coping skills = 3.8 [1.7-8.7]; AOR = 4.0 [3.1, 4.9]
Community group involvement	Do you participate in any community groups or volunteer groups?	NA	BS		OR for no community group involvement = 2.0 [0.6-7.0]

Attend church	Do you attend religious services? How often?	NA	BS	OR for no church attendance = 1.4 [0.7-3.1]
Depression	Center for Epidemiological Studies Depression Scale (CES-D)	α = .85-.90 across studies (Radloff, 1977)	EH	OR = 2.2 [0.98-5.1]
Needed treatment for mental health issues in the last year	Have you felt that you needed treatment for mental health issues in the last year?	NA	EH	OR = 2.2 [0.7-7.2]
Perceived economic hardship	Perceived Economic Hardship Scale[g]	Not reported	PS	OR = 2.1 [0.98-4.3]
Self-rated health	SF-36 Health Survey[h] (Ware, Kosinski, Dewey, & Gandek, 2000)	[illegible], α > .80; α > .90 in the physical and mental health sections (McHorney, Ware, Lu, & Sherbourne, 1994)	PS	OR for poor or fair self-rated health = 1.6 [0.7-3.9]
Perceived neighborhood safety	Do you perceive that your neighborhood is safe at night?	NA	PS	OR for unsafe neighborhood = 1.7 [0.8-3.6]

2	Chen (2011)	Review	NS	Daily chronic stressors	Daily Hassles Scale (Kanner, Coyne, Schaefer, & Lazarus, 1981)	Test-retest reliability: 0.79 (frequency) and 0.48 (intensity)	ES	NA	NA	NA	PTB LBW	NA
					Everyday Problems Checklist (Vingerhoets & Van Tilburg, 1994)	Test-retest reliability: 0.87 (frequency), 0.76 (severity), 0.85 (total)						
3	Dominguez (2008)	Review	B	Interpersonal and institutional racism	NA	NA	PS	NA	Before and during pregnancy	NA	PTB, LBW, and infant mortality	NA
4	Dunkel Schetter (2011)	Review	NS	Low SES	NA	NA	ES	NA	NS	NA	PTB, LBW	NA
				Perceived racism and discrimination, role strain			PS					
5	Dunkel Schetter (2012)	Review	NS	Unemployment, crowding	NA	NA	ES	NA	During pregnancy	NA	PTB, LBW	NA
				Racism or discrimination			PS					

6	Dunkel Schetter (2013)	Descriptive	W, B, H	Financial stress[i]	Developed by the research team	α = .69 (English) and .68 (Spanish)	ES	Individual	Before the next pregnancy	Before the next pregnancy (1 month after the recent delivery [Time 1])	NS (adverse birth outcomes of the next pregnancy given a prospective study design)	Not reported
				Pregnancy stress[j]	Adapted Prenatal Psychosocial Profile (10-item brief version; Curry, Burton, & Fields, 1998; Curry, Campbell, & Christian, 1994)	α = .76 (English) and .75 (Spanish)	ES			Before the next pregnancy (Time 1)		
				Life events 1: Life event count[k] 2: Life impact count[l]	Adapted Life Events Inventory (Dominguez, Schetter, Mancuso, Rini, & Hobel, 2005)	Not reported	1: ES 2: PS			Before the next pregnancy (Time 1 and 12 months after the recent delivery [Time 3])		
				Chronic stress (extra measures; see Stapleton et al. (2015) for details)	Adapted UCLA Life Stress Interview (Hammen et al., 1987)	α = .65 (English) and .59 (Spanish) across the four domains	ES, BS, PS			Before the next pregnancy (6 months after the recent delivery [Time 2])		
				Perceived stress	Perceived Stress Scale (10-item brief version; Cohen, Kamarck, & Mermelstein, 1983)	Time 1 α = .83 (English and Spanish) Time 2 α = .85 (English) and .79 (Spanish)	PS			Before the next pregnancy (Time 1, 2, and 3)		

				Interpersonal violence[m]	Adapted HITS (O'Campo, Caughy, & Nettles, 2010)	⍺ = .74 (English and Spanish)	ES			Before the next pregnancy (Time 1 and 3)		
				Perceived racism	Everyday Discrimination Scale (Williams, Yu, Jackson, & Anderson, 1997)	⍺ = .89 (English) and .88 (Spanish) when scored for any unfair treatment regardless of attribution	PS			Before the next pregnancy (Time 1 and 3)		
				Parenting stress[n]	Parenting Stress Index (Abidin, 1990)	⍺ = .92 (English) and .94 (Spanish)	ES, PS			Before the next pregnancy (Time 3)		
7	Ghosh (2010)	Data-based	NHW, B, H, A or other but target H (US-born versus foreign-born)	Perceived stress	4 questions[o] from the Perceived Stress Scale (Cohen et al., 1983)	Internal consistency reliability: 0.84-0.86 Test-retest reliability over 2 days (0.85) and over 6 weeks (0.55)	PS	Individual	During pregnancy	3-6 months after delivery	PTB	AOR[p] = 1.46 [1.11, 1.92] for entire cohort; AOR = 1.78 [1.03, 3.07] for US-born Hispanics; AOR = 1.26 [0.85, 1.85] for foreign-born Hispanics
8	Guendelman (2008)	Data-based	Not of interest (NHW, H, and other racial/ethnic groups of women who had worked 20h or more	Annual household income in the lowest tertile, not high school graduate, physically stressful job,[q] and work schedule exceeding 40h per week in the trimester preceding pregnancy	NA	NA	ES	Individual and cumulative (0, ≥ 1, ≥ 2, or ≥ 3 of the 7 stressors after excluding missing values for any stressor)	During pregnancy	Within 4.5 months of delivery on average	PTB	Not significant, alone or in combination after adjusting for race and month of birth (data not shown)

			per week during the first two trimesters of pregnancy or throughout the study)	Lacked instrumental support, lacked emotional support, sleep less than 6h/night	NA	NA	BS					
				Often felt strong anger in second trimester	NA	NA	EH					
				Often felt stress in second trimester	NA	NA	PS					
				Unfair treatment because of race/ethnicity	NA	NA	PS					
				Job is not fulfilling, high effort/low reward, and over-commitment to work	Siegrist's Effort Reward Imbalance scale (Siegrist, 1996)	Usually α > .70 of the three scales of effort, reward, and over-commitment (Siegrist, Li, & Montano, 2013)	PS					
				Low decision/high demand	Karasek's Job Content Questionnaire (Karasek & Theorell, 1992)	Internal consistency of the scales is generally acceptable and tends to be similar across populations and between men and women; α = .73 (women) and .74 (men; Karasek et al., 1998)	PS					
9	Hobel (2008)	Review	NS	Daily hassles, acculturation stress, crowding	NA	NA	ES	Individual and cumulative	NA	NA	PTB, LBW	NA

							BS					
				Coping mechanisms								
							EH					
				Distress, anxiety, negative affect, depression, pregnancy-related anxiety								
							PS					
				Household strain, job stress, marital strain								
10	Hoffman (1996)	Review	NS	Marital, occupational, and/or household role strain and institutional or individual racism	NA	NA	PS	NA	Before and during pregnancy	NA	Intrauterine growth or GA	NA
11	Latendresse (2009)	Review	NS	Poverty, domestic violence	NA	NA	ES	NA	Before and during pregnancy	NA	PTB	NA
							EH					
				Depression, anxiety								
							PS					
				Discrimination, perceived stress								

12	Rich-Edwards (2001)	Descriptive	B	Past and current experiences of racial discrimination	Adapted and expanded version of the questions used by Krieger in the CARDIA study[r] (Krieger & Sidney, 1996)	Not reported	PS	Individual	Before (childhood, adulthood) and during pregnancy	During pregnancy	PTB	NA
				Externalized and internalized emotional reactions to personal discrimination			EH					
				Political actions taken by the participant and her family in response to racial discrimination			BS					
			W, B, H, A, other	Past and current experiences of physical or sexual violence and lasting fear of physical or sexual attack[s]	Adapted and expanded version of the Personal Safety Questionnaire on the Abuse Assessment Screen (ASS; only the items about experiences of personal violence; McFarlane & Parker, 1994)	Not reported	ES		Before (as a child [up to age 11], teenager [age 12-17], adult [from age 18 until this pregnancy) and during pregnancy			
				Long-term emotional responses			EH					
				Immediate and long-term safety-seeking actions			BS					

13	Rich-Edwards (2005)	Review	B	Poverty	NA	NA	ES	NA	Lifelong exposures	NA	PTB	NA
				Racism, lack of neighborhood safety			PS					
14	Stapleton (2015)	Descriptive	W, B, H	Neighborhood noise, familiarity/problem with neighbors; conflict with family; conflict and resolution with partner; parental involvement, ability to work together as parents, criticism or undermining of parenting, and conflict around how to parent.	Adapted UCLA Life Stress Interview (Hammen et al., 1987)	ω = .65 (English) and .59 (Spanish) across the four domains	ES	Cumulative (ratings for each of the four domains [i.e., neighborhood, family, partner, and co-parenting sections] were averaged into a single index of overall chronic stress whose scores ranged from 1 to 5.)	Before pregnancy	Before the next pregnancy (Time 2)	NS	NA
				For the family section, availability/contact with family (excluding partner), closeness/trust, support and dependability; for the partner section, relationship's commitment and stability, closeness/trust, support and dependability.			BS					

				Lack of neighborhood safety			PS					
15	Strutz (2014)	Data-based	NHW, NHB, H (Mexican- and other-origin)	Low parent educational attainment, parent received public assistance, low parent income, parent could not pay bills, low respondent educational attainment, no health insurance, English as a second language, not born a US citizen, living without either biological parent, low neighborhood household education, high neighborhood poverty, and high neighborhood unemployment	NA	NA	ES	Cumulative (generating factor scores for the chronic stressors by using confirmatory factor analysis)	Before pregnancy	Before pregnancy	BW (gram)	The effect of race/ethnicity on BW decreased, and that for first births to other-origin Hispanics was no longer significant when chronic stress was adjusted; Adjusted[r] β = -139 [-233, -44] for first births; Adjusted β = -122 [-263, 19] for second births
16	Wadhwa (1993)	Data-based	Not of interest, but include W, B, H, A or other	Perceived stress	Perceived Stress Scale (Cohen et al., 1983)	Internal consistency reliability: 0.84-0.86 Test-retest reliability over 2 days (0.85) and over 6 weeks (0.55)	PS	Cumulative (standardized scores of chronic stress, daily hassles, and strain were summed to create a composite variable "perceived stress")	During pregnancy	28th and 30th week	BW, GA, and 1- and 5-minute Apgar scores	Not significant in a bivariate analysis even before controlling for biomedical risk

17	Wilson (2015)	Data-based	Non-H vs. H and W vs. non-W	Stressful life events categorized into partner, emotional, traumatic, or financial stress	NA	NA	ES	Cumulative (0 = no response to all questions in all of the stress categories, 1 = at least one yes in only one of the four categories, 2 = at least one yes in each of two of the four categories, 3 = at least one yes in each of three of the four categories, and 4 = at least one yes in all four categories)	During the 12 months before pregnancy	2 months after delivery	BW (gram)	Race/Ethnicity did not have an independent effect on BW with other risk factors held constant, including cumulative stress; β = -15.6 ($p \leq .05$, 95% CI not presented)[u]

NHW = Non-Hispanic White, NHB = Non-Hispanic Black, ES = External Stressor, LBW = Low Birthweight, OR = Odds Ratio, AOR = Adjusted Odds Ratio, NA = Not Applicable, BS = Buffers of Stress, EH = Enhancers of Stress, PS = Perceived Stress, NS = Not Specified, PTB = Preterm Birth, B = Black, W = White, H = Hispanic, A = Asian, GA = Gestational Age, BW = Birthweight

[a]Questions directed at determining issues such as household plumbing/heat/telephone problems, rodent or insect infestation, or having had to borrow money from friends or family to pay bills.

[b]Questions directed at determining ability to afford the needed food for a household.

[c]Adjusted for maternal age.

[d]Divorce, family member killed, robbed, arrested, hospitalization, or long illness.

[e]Respondents' perceptions of their level of emotional social support are assessed by asking whether they have enough people, too few people or no one to count on in various situations (i.e., lend money, listen to problems and help with small favors). Answers for each item range from 1 (on one) to 3 (enough people).

[f]Internal consistency with Cronbach's alpha coefficient.

[g]Questions directed at determining the status of an individual's financial situation, such as whether she worries about having enough money in the future or can generally afford to buy the things she needs.

[h]Poor or fair health versus good or very good or excellent health.

[i]Questions on SES, objective finances (e.g., household income, public assistance) and other 5 items indicative of financial stress (e.g., relative financial status compared to an earlier time period [better, worse, same], the degree of difficulty meeting monthly expenses, whether household income was adequate to meet expenses, and two items about food insecurity).

[j]Money worries, problems with family, work problems, and being generally overloaded during pregnancy.

[k]Of 24 events that occurred in the past year, two items from the original tool (i.e., sexual and racial discrimination or harassment) were deleted because they were covered in other measures. One additional item (complications in the recent pregnancy) was included in the Time 1 life event list.

[l]Each life event was followed by the question "How was this experience for you personally?" with seven response options (7: very negative or undesirable, 1: very positive or desirable).

[m]A four item questionnaire in which respondents were asked how often their partner physically Hurt, Insulted, Threatened with harm, and Screamed at them (HITS).

[n]A 36-item instrument asks parents the degree to which they agree with statements on a 5-point scale referring to aspects of dysfunctional parent-child interaction, parental distress, and difficult child characteristics. Examples include "I feel trapped in my responsibilities as a parent" and "My child generally wakes up in a bad mood."

[o]How often the woman felt: (1) she was able to control the important things in her life, (2) had difficulties piling up so high she felt she could not overcome them, (3) she was confident about her ability to handle her personal problems, and (4) things were "going her way" during her pregnancy. Chronic stress responses were recorded on a five-point Likert scale (never, almost never, sometimes, fairly often, very often) and summed to create a score (4-8 low, 9-12 moderate, 13-20 high stress).

[p]Adjusted for partner support, maternal age, race/ethnicity, and marital status.

[q]Exposure to at least one of a number of physical stressors, including bending at least 10-times per hour, standing for more than 4h, carrying or lifting heavy items weighing more than 15 pounds on a daily basis, operating heavy machinery, and exposure to high levels of noise or uncomfortable temperatures.

[r]The questionnaire asks about experiences of 'unfair treatment because of race or ethnicity' in eight domains, such as 'at work' or 'getting housing.' Separately, the participants' perception of discrimination towards her ethnic group and herself was assessed.

[s]The questionnaire asks whether women had ever witnessed or feared harm to other people in their home.

[t]Adjusted for maternal race/ethnicity, preconception body mass index, cigarette smoking, heavy drinking, marital or cohabitation status at preconception and at birth, age at birth, and time between preconception interview and birth.

[u]Adjusted for race/ethnicity, percent federal poverty level, education, marital status, smoking during last 3 months of pregnancy, drinking during last 3 months of pregnancy, maternal age, BMI, cumulative depression, and cumulative abuse.

CHAPTER 3: PAPER 2

Factor Structure for Chronic Stress Before and During Pregnancy by Racial/Ethnic Group

*Sangmi Kim, MPH, RN, sangmik@nursing.upenn.edu
**Eun-Ok Im, PhD, MPH, RN, CNS, FAAN, eun-ok.im@duke.edu
*Jianghong Liu, PhD, RN, FAAN, jhliu@nursing.upenn.edu
*Connie Ulrich, PhD, RN, FAAN, culrich@nursing.upenn.edu

Author Note

*University of Pennsylvania School of Nursing, Claire M. Fagin Hall
418 Curie Blvd., Philadelphia, PA 19104
**Duke University School of Nursing, 307 Trent Drive, Durham, NC 27710

Address for Correspondence:

Sangmi Kim, MPH, RN
Email: sangmik@nursing.upenn.edu / Phone: 484-821-7337

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Abstract

Objective: This study aimed to explore race/ethnicity-specific dimensionalities of chronic stress before and during pregnancy for non-Hispanic (N-H) White, N-H Black, Hispanic, and Asian women in the U.S.

Methods: This study analyzed the data among 6,850 women from the New York City and Washington State Pregnancy Risk Assessment Monitoring System (2004–2007) linked with birth-certificate data. 26 chronic stress items before and during pregnancy were extracted from the data for analysis based on a systematic literature review. Separate exploratory factor analysis was conducted by race/ethnicity using a maximum-likelihood extraction method without rotation. Correlations and internal consistency reliabilities (Cronbach's alpha) among items and latent factors were evaluated to determine race/ethnicity-specific factor structures of chronic stress.

Results: Chronic stress before and during pregnancy was race/ethnicity-specific and multidimensional with low correlations among the latent factors (r = .07-.28, $p < .05$). Financial hardship, perceived isolation, and physical violence were shared chronic stress experiences among the racial/ethnic groups (factor loading: .36-.85; Cronbach's alpha: .64-.83) although physical violence seemed more influential in Black communities than in others. Intergroup variations also existed in chronic stress experience, physical violence in particular, that can be understood in each racial/ethnic group's cultural, sociopolitical, or immigration contexts.

Conclusions: Chronic stress is suggested as an important construct accounting for the racial/ethnic differences in adverse birth outcomes. Both shared and unique chronic

stressors experienced by each racial/ethnic group can be used to develop targeted and culturally congruent strategies to improve reproductive potential of racial/ethnic minority women.

Keywords: chronic stress, dimensionality, racial/ethnic differences, PRAMS

Introduction

Despite the persisting racial/ethnic disparities in such adverse birth outcomes as preterm birth (PTB; < 37 weeks' gestation) and low birth weight (LBW; < 2,500 g of birth weight), their mechanisms are poorly understood (Culhane & Elo, 2005). Recently, increasing attention has been paid to the role of psychosocial factors in such etiologies of adverse birth outcomes as stressful life events, perceived stress, anxiety, depressive symptoms, and chronic stress (McDonald, Kingston, Bayrampour, Dolan, & Tough, 2014). Although stressful life events, as a validated measurement of acute stress, have been widely used to explain racial/ethnic minority women's excess risk of adverse birth outcomes, they are known to systematically underestimate exposure to stress of Blacks or individuals with lower socioeconomic status (SES) relative to their White or more privileged counterparts (Turner, 2010).

Alternatively, chronic stress has been suggested as an important indicator to measure the racial/ethnic disparities in adverse birth outcomes because chronic stress is pervasive in the lives of racial/ethnic minority women and exerts a greater impact on their reproductive health than does acute stress (Kramer et al., 2001; Strutz et al., 2014). In contrast to measuring stressful life events, however, the measurement of chronic stress before and during pregnancy is less standardized across studies, resulting in numerous operational definitions of chronic stress used to estimate adverse birth outcomes. In the existing literature, chronic stress before and during pregnancy is represented, either independently or in combination, by a wide spectrum of maternal factors over the life course, including low SES (e.g., financial stress, home crowdedness, low educational

attainment, unemployment, difficulties obtaining medical care, and food insecurity; Borders, Grobman, Amsden, & Holl, 2007; Dunkel Schetter et al., 2013; Dunkel Schetter & Tanner, 2012; Guendelman, Lang Kosa, Pearl, Graham, & Kharrazi, 2008; Hobel, Goldstein, & Barrett, 2008; Latendresse, 2009; Rich-Edwards & Grizzard, 2005; Strutz et al., 2014), early life stress (Strutz et al., 2014), neighborhood stress (e.g., neighborhood noise, familiarity/problem with neighbors, and low neighborhood SES; Stapleton et al., 2015; Strutz et al., 2014), domestic violence and/or lasting fear (Dunkel Schetter et al., 2013; Latendresse, 2009; Rich- Edwards et al., 2001), daily chronic stressors (Chen, Grobman, Gollan, & Borders, 2011; Hobel et al., 2008), acculturation stress (Hobel et al., 2008; Strutz et al., 2014), interpersonal stress (Stapleton et al., 2015), parenting stress (Dunkel Schetter et al., 2013; Stapleton et al., 2015), pregnancy stress (Dunkel Schetter et al., 2013), physically stressful job (Guendelman et al., 2008), child with chronic illness in the home (Borders et al., 2007), racism (Dominguez, 2008; Dunkel Schetter, 2011; Dunkel Schetter et al., 2013; Dunkel Schetter & Tanner, 2012; Guendelman et al., 2008; Hoffman & Hatch, 1996; Latendresse, 2009; Rich-Edwards & Grizzard, 2005; Rich- Edwards et al., 2001), role strain (e.g., work, household, and marital strain; Dunkel Schetter, 2011; Guendelman et al., 2008; Hobel et al., 2008; Hoffman & Hatch, 1996), perceived stress (Borders et al., 2007; Dunkel Schetter et al., 2013; Ghosh, Wilhelm, Dunkel-Schetter, Lombardi, & Ritz, 2010; Guendelman et al., 2008; Latendresse, 2009; Wadhwa, Sandman, Porto, Dunkel-Schetter, & Garite, 1993), lack of neighborhood safety (Borders et al., 2007; Rich-Edwards & Grizzard, 2005; Stapleton et al., 2015), lacking personal and/or social coping resources/strategies (Borders et al., 2007; Guendelman et al., 2008; Rich- Edwards et al., 2001; Stapleton et al., 2015), inadequate

sleep (Guendelman et al., 2008), and psychological distress (e.g., depression and anxiety; Borders et al., 2007; Guendelman et al., 2008; Hobel et al., 2008; Latendresse, 2009; Rich- Edwards et al., 2001). Even stressful life events were utilized in some studies to capture women's cumulative stress underlying their adverse birth outcomes (Borders et al., 2007; Dunkel Schetter et al., 2013; Wilson, Dyer, Latendresse, Wong, & Baksh, 2015).

Research by far has a tendency to focus on isolated chronic stressors experienced before and during pregnancy to predict women's adverse birth outcomes. However, in fact, multiple stressors often co-occur in an ecological context and may interactively influence health outcomes (Troxel, Matthews, Bromberger, & Sutton-Tyrrell, 2003). Wadhwa, Entringer, Buss, and Lu (2011) argued that distinction between various components or dimensions of psychological stress as discrete entities may be somewhat arbitrary because different components of psychological stress are not randomly distributed, but tend to co-occur with one another. Aggregating across multiple sources of stress may increase the predictive power of individual stress measures and may be a more valid representation of the way stress operates to degrade one's health potential (Troxel et al., 2003). If a set of stress measures inter-correlates, their combined use as a measured variable or latent factor should increase the quality of the stress measure and the power to detect its effect on health outcomes (Dunkel Schetter, 2011).

Furthermore, few studies have paid much attention to distinctive components of chronic stress relevant to each racial/ethnic group of women to account for their adverse birth outcomes. To examine how stress contributes to poor health outcomes, the

operationalization and measurement of stress must be culturally relevant, taking into consideration the context of racial/ethnic minority women's lives (Woods-Giscombé, 2010). It may be possible that the underlying factors and the factor structure of chronic stress vary as a function of race/ethnicity because racial/ethnic groups are likely to experience and report different types of stress, or the same stress to varying degrees (Dominguez, Schetter, Mancuso, Rini, & Hobel, 2005). For example, compared to N-H White women among the several domains of stressful life events in the 12 months before delivery, N-H Black women were 13% more likely to report emotional stressors and 48% more likely to report partner-associated stressors, whereas American Indian/Alaska Native and Hispanic women were significantly more likely to report traumatic stressors and Asian/Pacific Islander women were less likely to report emotional stressors, when socio-demographic differences were controlled (Lu & Chen, 2004). Besides, Hispanics, relative to N-H Whites, are inclined to respond in a socially desirable manner such that some may be reluctant to disclose problems in areas that highly valued (i.e., relationship stress) or that carry a stigma (i.e., family substance abuse; Gallo, Jiménez, Shivpuri, De Los Monteros, & Mills, 2011). These findings support the idea of the variability of significant or prevalent chronic stressors before and during pregnancy, at least among those self-reported or measured by instruments, across racial/ethnic groups.

The purpose of this study is to assess race/ethnicity-specific dimensionalities of chronic stress before and during pregnancy for N-H White, N-H Black, Hispanic, and Asian women. The hypothesis is that an underlying factor structure of chronic stress before and during pregnancy differs by race/ethnicity.

Methods

Data Source and Setting

This study was a secondary data analysis using NYC (New York City) and WA (Washington State) Prenatal Risk Assessment Monitoring System (PRAMS) data between 2004 and 2007. Originally, the PRAMS projects are collaborative efforts with 34 states. Every month each participating state selects a sample of newly delivered mothers from live birth certificates by stratified random sampling without replacement to receive a mailed questionnaire. Participating states sample between 1,300 and 3,400 women each year (Centers for Disease Control and Prevention [CDC], 2012). The PRAMS questionnaire consists of two parts, core and standard/state-developed questions. The core questionnaire collects information on (a) attitudes and feelings about the most recent pregnancy, (b) content and source of prenatal care, (c) maternal alcohol and tobacco consumption, (d) physical abuse before and during pregnancy, (e) pregnancy-related morbidity, (f) infant health care, (g) contraceptive use, (h) mother's knowledge of pregnancy-related health issues (e.g., adverse effects of tobacco and alcohol), (i) benefits of folic acid, and (j) risks of HIV (CDC, 2015a). The standard/state-developed questionnaire is composed of a pretested list of standard questions developed by the CDC or developed by states on their own. As a result, each state's PRAMS questionnaire is unique (CDC, 2015b). States mail questionnaires 2 to 6 months after delivery and follow-up with a telephone interview for nonrespondents. The final PRAMS data are weighted for sample design, nonresponse, and noncoverage to allow construction of population estimates representative of all women who gave birth in each state participating in the

PRAMS during the specified years (CDC, 2012). To minimize nonresponse bias, the CDC PRAMS' working group set a response rate threshold of 65–70% (CDC, 2015a).

Only New York City and Washington State data (2004-2007) were analyzed from the 34 participating states and New York City because only these two local PRAMS collected two extra measures of chronic stress from the standard/state-developed questionnaire (race bias and social support) in addition to the variables from the core questionnaire. Race bias and social support are essential for the more accurate assessment of chronic stress experienced by racial/ethnic minorities.

Sample

The analytic sample consisted of women who (a) identified themselves as non-Hispanic [N-H] White, N-H Black, Hispanic, or Asian and (b) delivered live singleton birth registered in NYC or WA between 2004 and 2007. A total of 9,371 women (2,846 N-H White, 2,082 N-H Black, 3,009 Hispanic, and 1,440 Asian) participated in the PRAMS survey. Among them, 2,521 women (26.9%) were excluded due to missing information on the proxy variables of chronic stress before and during pregnancy used for analysis (discussed below). The fact that racial/ethnic minorities, relative to N-H Whites, tended to have more missing information might not necessarily produce biased results among the groups because statistical analysis in this study was conducted stratified by race/ethnicity. Subsequently, the study subjects were 6,850 women (2,314 N-H White, 1,476 N-H Black, 1,999 Hispanic, and 1,061 Asian) who recently gave singleton birth in NYC or WA during the specified survey period.

Measures

Through a systematic literature review (see Paper 1), chronic stressors before and during pregnancy were identified, which reportedly resulted in adverse birth outcomes among four racial/ethnic groups. Then, proxy variables of chronic stress considered to measure the equivalent chronic stressors found in the literature were extracted from the data. A total of 26 items were included in analysis: race bias, total household income, maternal educational attainment, health insurance before pregnancy, Medicaid before pregnancy, unaffordable prenatal care, special supplemental nutrition program for Women, Infants, and Children (WIC) during pregnancy, physical abuse before pregnancy, physical abuse during pregnancy, 13 items of stressful life events from four distinct domains, such as emotional (e.g., sick/hospitalized family member, demise of someone very close), financial (e.g., job loss, difficulty paying bills), partner-related (e.g., separation or divorce, unwanted pregnancy by husband/partner), and traumatic stress (e.g., homelessness, imprisonment of partner/self; Lu & Chen, 2004), and 4 items of social support (e.g., money, care, ride, and talk; see Table 2).

Of these items, total household income, maternal educational attainment, health insurance before pregnancy, and social support were reverse-coded such that one's unfavorable SES and lack of social support indicated higher levels of chronic stress.

Statistical Analyses

The data were analyzed by exploratory factor analysis using a maximum-likelihood extraction method. Considering a categorical nature of the variables analyzed, a polychoric correlation was examined in each pair of the variables in advance. A model

was fit to each of four racial/ethnic groups. The number of extracted factors was chosen on the basis of both a scree plot of the eigenvalues (higher than one) and factor interpretability. The factor solution was not rotated to give an opportunity for items to load to more than one factor and not to force factors to be uncorrelated for a simplified factor structure because domains of chronic stress can correlate. By doing so, it can reveal a natural factor structure of chronic stress for each racial/ethnic group (Osborne, 2015). A sensitivity test with Varimax rotation did not show major differences from the un-rotated result. Although factor loadings with values of at least .40 were deemed salient in most cases, a few exceptions were allowed to interpret factors by selecting items whose factor loading was between .35 and .40 (Sodowsky, Taffe, Gutkin, & Wise, 1994). Subscales, depending on emerged factors, were formed from the items with salient loadings to each factor. Then, full scale and subscale correlations and internal consistency reliabilities (Cronbach's alpha), respectively, were computed among latent factors and items. Only latent factors with Cronbach's alpha of the items greater than .60 were kept in the model.

The analysis weight in the PRAMS data was included throughout the modeling process to adjust for the sample selection, non-response, and non-coverage (omitted sample frame). The analysis weight for the entire population was applied in each racial/ethnic subsamples from the PRAMS data where not only do each group of N-H Black, Hispanic, and Asian women have different sampling rates than the other groups, but also they have different sampling rates within each group in some cases (B. Morrow, personal communication, June 9, 2017). The weight can be interpreted as the number of women like herself (N-H White, N-H Black, Hispanic, or Asian mothers delivering live

singleton birth) in the population that NYC or WA represents during 2004–2007 (CDC, 2016). All analyses were conducted using SAS Version 9.4 statistical software (SAS Institute, Inc., Cary, NC). This study was exempt from IRB approval.

Results

Descriptive Statistics

Table 1 shows subject's characteristics by race/ethnicity. The results found that N-H Black and Hispanic women had worse socioeconomic and psychological risk profiles relative to N-H White and Asian women. Three racial/ethnic minority groups were more likely than N-H White women to experience race bias and poor social support. N-H Black and Hispanic women were approximately twice as more likely to be a victim of physical violence as N-H White women. Only noticeable differences between women in NYC and in WA were that the former was more likely than the latter to be racially/ethnically diverse, on Medicaid or WIC, and poor (data not shown).

Underlying Factors of Chronic Stress by Race/Ethnicity

The race/ethnicity-specific analysis showed both commonalities and variations in the dimensionality of chronic stress before and during pregnancy among four racial/ethnic groups (see Figure 1).

N-H Whites. A total of three factors—financial hardship, perceived isolation, and physical violence—emerged with eigenvalues greater than one, and together they accounted for 80.1% of the total variance. The eigenvalues of the three factors were 9.39, 3.20, and 2.05.

Financial hardship (Factor 1) included six items, including a lot of bills that can't be paid, Medicaid before pregnancy, maternal education, health insurance before pregnancy, WIC during pregnancy, and household income. *Perceived isolation (Factor 2)* consisted of four items, including "someone to loan me $50," "someone to help me if I were sick and needed to be in bed," "someone to take me to the clinic or doctor's office if I needed a ride," and "someone to talk with about my problems." *Physical violence (Factor 3)* consisted of three items referring to a physical fight during pregnancy, physical abuse by a husband/partner before pregnancy, and physical abuse by a husband/partner during pregnancy. The internal consistency reliability for each factor ranged from .65 to .77 (see Table 3).

N-H Blacks. Initially, four factors emerged with eigenvalues greater than one. Factor 4, however, had only two items (a lot of bills that can't be paid and argument with a husband/partner more than usual) with 1.42 of eigenvalue and 0.38 of Cronbach's alpha. Considering its weak internal consistency reliability, the factor was excluded by forcing the model to contain only three factors. No difference was found among the remaining three factors with or without the predetermined number of factors. Thus, a total of three factors—financial hardship, physical violence, and perceived isolation—accounted for 75.4% of the total variance. Their eigenvalues were 6.14, 3.82, and 2.92.

Financial hardship (Factor 1) included four items, including health insurance before pregnancy, WIC during pregnancy, maternal education, and household income. *Physical violence (Factor 2)* consisted of three items referring to a physical fight during pregnancy, physical abuse by a husband/partner before pregnancy, and physical abuse by

a husband/partner during pregnancy. *Perceived isolation (Factor 3)* consisted of the four means of social support as mentioned above (e.g., money, care, ride, and talk). The internal consistency reliability for each factor ranged from .71 to .76 (see Table 3).

Hispanics. A total of three factors—financial hardship, perceived isolation, and physical violence—emerged with eigenvalues greater than one, and together they accounted for 76.1% of the total variance. The eigenvalues of the three factors were 4.96, 3.08, and 2.48.

Financial hardship (Factor 1) included four items, including health insurance before pregnancy, maternal education, WIC during pregnancy, and household income. *Perceived isolation (Factor 2)* consisted of four items reflective of the four different means of support. *Physical violence (Factor 3)* consisted of four items referring to being separated or divorced from a husband/partner, physical abuse by a husband/partner before pregnancy, physical abuse by a husband/partner during pregnancy, and argument with a husband/partner more than usual. The internal consistency reliability for each factor ranged from .64 to .78 (see Table 3).

Asians. Like N-H Blacks, chronic stress among Asians initially had four factors with eigenvalues greater than one. Factor 4, however, was excluded from the model since it influenced three items (job loss of a husband/partner, a problem with drinking or drugs of someone very close to her, and argument with a husband/partner more than usual) whose eigenvalue was 1.27 and Cronbach's alpha was 0.36. Then, the model was forced to retain only three factors. A total of three factors—financial hardship, perceived

isolation, and physical violence—accounted for 76.7% of the total variance. Their eigenvalues were 8.14, 4.79, and 3.09.

Financial hardship (Factor 1) included four items, including health insurance before pregnancy, maternal education, WIC during pregnancy, and household income. *Perceived isolation (Factor 2)* consisted of the four items of social support. Although the item of monetary support had a lower factor loading than .40, it was not excluded because the four items altogether were validated to measure social support by the PRAMS team in the CDC. *Physical violence (Factor 3)* consisted of four items referring to physical abuse by a husband/partner before pregnancy, unwanted pregnancy by a husband/partner, physical fight during pregnancy, and imprisonment of self or a husband/partner. The internal consistency reliability for each factor ranged from .64 to .83 (see Table 3).

Multifactorial Model vs. Hierarchical Model

Correlations among the factors within each racial/ethnic group were small according to Cohen's criteria (Cohen, 1988). For example, the factor correlations (among only those statistically significant) for N-H White, N-H Black, Hispanic, and Asian women ranged between .23 and .28; .07 and .24; .09 and .15; .07 and .23, respectively (see Table 4). This result did not seem to lend strong support to the existence of a more general higher order factor that could account for the first-order factors. Thus, the structures of chronic stress before and during pregnancy among the racial/ethnic groups were multifactorial.

Discussion

This study found that four racial/ethnic groups had distinctive chronic stress experiences before and during pregnancy. The following discussions about common and unique features of chronic stress for the racial/ethnic groups would contribute to deepening our understanding of each group of women's lived experiences as a community that increase its vulnerability to adverse birth outcomes.

Common Features

As indicated in the results section, three underlying factors of chronic stress without a hierarchy emerged among four racial/ethnic groups. The existence of multiple components of chronic stress has been acknowledged and reflected in its definitions or instruments intended to measure it. For example, Dunkel Schetter and Dolbier (2011) defined chronic stress as ongoing demands that threaten to exceed the resources of an individual in areas of life such as family, marriage, parenting, work, health, housing, and finances. In addition, UCLA Life Stress Interview assesses chronic stress over at least the past 6 months in various role domains, such as quality of intimate (romantic) relationship, close friendships, social life, relations with family members (children, parents, and siblings), finances, work, health of self, and health of family members (Hammen et al., 1987). Similarly, Bromberger and Matthews (1996) developed a chronic stress measure for midlife women by adapting eight major life domains of the Psychiatric Epidemiology Research Interview Life Events Scale: personal health-related, family health-related, family drug/alcohol-related, work, financial, housing-related, caregiving, and relationship stress. These matrices appear to capture the overlapping aspects of stressful conditions.

Extracted constructs of financial hardship and physical violence are within the boundary of the known domains of chronic stress. Physical violence can be considered as a relationship-related stress in a broader context. First of all, low SES and subsequent financial difficulties are correlated with exposure to stressful environments and conditions that contribute to chronic stress (Baum, Garofalo, & Yali, 1999). As cited earlier in this article, a variety of financial hardship measures (e.g., financial strain, food insecurity, poor home environment, low educational attainment, low household income, poverty, unemployment, and no access to appropriate health care) represented chronic stress as a risk factor for adverse birth outcomes across racial/ethnic groups (Borders et al., 2007; Dunkel Schetter et al., 2013; Dunkel Schetter & Tanner, 2012; Guendelman et al., 2008; Hobel et al., 2008; Latendresse, 2009; Rich-Edwards & Grizzard, 2005; Strutz et al., 2014). Braveman et al. (2015) observed no significant Black-White disparity in PTB within the most socioeconomically disadvantaged subgroups who were poor, had not completed high school, whose babies' fathers were unemployed, or lived in high-poverty census tracts. Chronic stress from such an underprivileged SES may have operated as a common causal pathway to PTB for both impoverished racial groups. Also, in a qualitative study among Puerto Rican women at the highest risk of PTB and LBW in Latina communities, low income/poverty and food insecurity were among the most predominant stressors perceived to affect their health and birth outcomes. Especially, these women, despite receiving WIC, felt stressed because such a food assistant program did not provide enough to feed the family for the entire month (Bermudez-Millan et al., 2011). In Asian communities, many immigrants face economic and occupational stress (e.g., downward mobility) as well throughout the migration and adaptation process,

resulting from racial/language discrimination and cultural conflicts (Chang, Shen, & Takeuchi, 2009; Lee, 2007).

The role of chronic stress played in the relationship between physical violence and women's health has also been reported in not only general populations but also specific racial/ethnic groups. Relative to women not experiencing intimate partner violence (IPV), victimized women exhibited higher hair cortisol levels—a promising biomarker of chronic exposure to stress (Boeckel, Viola, Daruy-Filho, Martinez, & Grassi-Oliveira, 2017). Also, Black pregnant women in urban Boston areas with a high cumulative stress of interpersonal violence, community violence, discrimination, and other negative life events showed a diurnal pattern of cortisol (i.e., lower morning cortisol level and flatter waking to bedtime cortisol slope) signaling the disrupted hypothalamic-pituitary-adrenal (HPA) axis in response to long-lasting stress, known to be associated with adverse birth outcomes, such as PTB (Suglia et al., 2010). Among low-income Mexican American women, general stress (i.e., perceived stress combined with economic hardship) and lower social support related to their IPV during pregnancy (Jackson et al., 2015). In addition, Southeast Asian battered women in Boston reported a range of health concerns (e.g., headache, backache, gastrointestinal problems, sleep disturbance, poor appetite, and diminished functional health) that erode their sense of wellbeing and quality of life through prolonged stress; some of the victims stated that they felt stress all the time (Hurwitz, Gupta, Liu, Silverman, & Raj, 2006).

Lastly, perceived isolation underlying a lack of social support (e.g., money, care, ride, and talk) was another significant component of chronic stress among the four racial/ethnic groups. Perceived isolation refers to the subjective experience of a shortfall

in one's social resources such as companionship and support (Cornwell & Waite, 2009). Hawkley and Cacioppo (2010) argued that those who chronically perceive social isolation feel unsafe, and accordingly, are implicitly hypervigilant for social threat in the environment, which entails feelings of stress, hostility, perceived distress (e.g., anxiety), and low personal coping resources (e.g., low self-esteem). Indeed, the biological pathways of chronic perceived isolation to morbidity and mortality are shared with those of chronic stress, including the development of chronic diseases, dysregulation of the HPA axis, and glucocorticoid resistance (Corwin et al., 2013; Hawkley & Cacioppo, 2010). Among women lacking paternal support, those experiencing moderate-to-high levels of chronic stress were more likely to experience PTB than those with low chronic stress. In contrast, chronic stress did not increase the risk of PTB within the group of women with moderate-to-high paternal support (Ghosh et al., 2010). Hurtado-de-Mendoza, Gonzales, Serrano, and Kaltman (2014) in their qualitative study documented social isolation and perceived barriers to establishing social networks among Latina immigrant women with trauma. These women mentioned both lacks of opportunity and affordability to spend time and money with family, friends, or neighbors, which contributed to their loneliness. They also pointed out difficulties developing a friendship and trusted relationship with others in the U.S. Feeling depressed or stressed worked as one of the psychosocial barriers to nurturing supportive relationships among the Latina immigrant women with traumatic experiences. Similarly, pregnant Southeast Asian women (Vietnamese, Cambodian, and Laotian) living in Canada, particularly those who were more acculturated, reported experiencing lots of stress, such as financial pressures and inadequate social support. They were worried about not having enough assistance at

home after the baby was born due to not many family members or friends around whom they could rely on for help (Hyman & Dussault, 2000).

Unique Features

Despite the same sources of chronic stress across the racial/ethnic groups, intergroup variances also existed in chronic stress experience, physical violence in particular, that can be understood in each racial/ethnic group's cultural, sociopolitical, or immigration contexts.

N-H Whites. A huge gap existed between financial hardship and perceived isolation/physical violence in the variance of chronic stress they explained (50.9% vs. 16.5/12.7%). In contrast, the racial/ethnic minority groups showed a relatively even distribution of the variance explained by each underlying factor. Indeed, Dunkel Schetter et al. (2013) documented how financial constraint was closely tied to N-H White women's stress experience than was to others. Specifically, relative to poor or near-poverty Black mothers, White mothers with the comparable condition reported significantly higher financial stress. This phenomenon could be attributed to differential responses to economic deprivation by race/ethnicity; possibly, greater resilience, different coping styles, and more habituation to financial hardship among Blacks may exert a somewhat protective effect.

Another consideration in interpreting the findings, however, would be the higher vulnerability of racial/ethnic minority women to multiple chronic stressors due to their intersecting identities and double jeopardy as non-White and woman in American society where racial/ethnic and gender disparities remain. Race and gender identities are interlocking and interdependent, which presents an unequal stress exposure and appraisal

(Bowleg, 2012; Woods-Giscombe & Lobel, 2008). Moreover, Hispanic or Asian immigrant women may face additional difficulties and stress during adaptation to a new culture, above and beyond those related to their race and gender. From the intersectionality perspective, the disproportionately small contribution of perceived isolation and physical violence to the chronic stress experience among N-H White women implies that this population may enjoy social privilege and benefits and utilize necessary resources to protect them from the risk of social isolation and physical violence. On the other hand, racial/ethnic minority immigrant women may be exceedingly vulnerable to violence because they are isolated from their friends and families due to the immigration experience. Many of these women also have undocumented or nonpermanent immigrant status, placing legal restrictions on them to seek help (Raj & Silverman, 2002). Similarly, acculturation-related stress among Asian immigrants, including social isolation, language barriers, limited economic resources, downward mobility, discrimination and racism, and clashing cultural values could increase the levels of distress and accordingly the families' susceptibility to IPV (Lee & Hadeed, 2009).

N-H Blacks. Only among N-H Black women, physical violence seemed as a more significant chronic stressor than perceived isolation given the greater proportion of variance explained by the former than by the latter. This finding mirrors how pervasive this public health issue is in Black communities. According to national statistics in 2011, an estimated 41.2% of N-H Black, 30.5% of N-H White, 29.7% of Hispanic, and 15.3% of Asian or Pacific Islander women experienced physical violence by an intimate partner during their lifetimes (Breiding, 2015). Also among abused women during pregnancy,

Black women's risk of becoming an attempted/completed femicide victim was more than three-folds the risk of their White counterparts (McFarlane, Campbell, Sharps, & Watson, 2002).

Gendered racism (Essed, 1991) experienced by Black women may amplify their vulnerability to IPV. A lack of economic resources among Black women resulting from racial and gender discrimination in education or employment opportunities may put them at increased risk of victimization as well as reduce likelihood to leave the relationship with their abusive partner (Perry, Harp, & Oser, 2013; West, 2004). Also, racist and sexist stereotype that views Black women as promiscuous may justify violence against Black women by blaming the victims (Perry et al., 2013; West, 2004). Moreover, Black women are reluctant to report her abuser and seek help because of a strong sense of cultural affinity and loyalty to community and race; deeply-rooted mistrust in law enforcement and a fear that police will abuse its power to harm Black people; fear of isolation, alienation, rejection from family, friends, congregation, and community when disclosing "dirty family secret" (Jones, 2014; West, 2004; Women of Color Network [WOCN], 2006). Their religious belief often discourages divorce and encourages to forgive her abuser's behaviors and to endure the abuse due to religious obligations under Christian doctrine (Jones, 2014; WOCN, 2006). Besides, Black women's perceived obligation to become a superwoman has them manifest strength and suppress emotions, which may contribute to conflicts with their intimate partners (Woods-Giscombé, 2010).

Hispanics. Physical violence problems in this population were displayed as a form of divorce/separation, increased argument with a partner, and a physical attack before and during pregnancy by a husband/partner. Not only is violence a risk factor for

ending a marital relationship, but also women's physical safety is threatened during or after a separation (Kurz, 1996). Despite the widespread misconception that ending the relationship will end the violence, it is common for batterers to continue or even escalate their violence after divorce/separation (Fleury, Sullivan, & Bybee, 2000). Mahoney (1991) used the term "separation assault" to describe a batterer's use of violence as a way to attempt to regain or maintain control over his ex-partner after she leaves. For instance, Hispanic women who were separated or divorced were approximately four times more likely to be a victim of physical violence than their married counterparts (Hazen & Soriano, 2007).

It is interesting that the items reflective of marital discord (e.g., divorce/separation and increased argument with a partner) were linked to physical violence only in the Hispanic community upholding *familismo* and *machismo* as central cultural values. *Familismo* emphasizes family unity and individual devotion to the family (Bauer, Rodriguez, Quiroga, & Flores-Ortiz, 2000). *Machismo* refers to excessive masculinity and male dominance (WOCN, 2006). Their traditional gender norm highly values and idealizes female subordination, stoicism, and selflessness (Bauer et al., 2000). Also, a widespread fear of stigmatization attached to divorce and remarriage among Hispanic women contributes to their tolerance of the partner's physical abuse and fewer efforts to seek outside help (Adames & Campbell, 2005; Bauer et al., 2000).

First-generation Mexican immigrant women reported the pervasive marital conflicts throughout their community and ascribed its causes to men's control over women, *machismo*, and men's inability to cope with changes related to immigration (Adames & Campbell, 2005). Indeed, marital conflicts may occur as a result of

differential acculturation between men and women or changes in family structure, gender roles, and power dynamics in the marriage over the acculturation process (Adames & Campbell, 2005; Flores, Tschann, VanOss Marin, & Pantoja, 2004). As immigrant families face severe financial difficulties, Hispanic women who might have stayed at home are increasingly joining the labor force (Perilla, Bakeman, & Norris, 1994). Thus, Hispanic women may expect to share control and power with her partner within the home as they make an equal contribution to the economic and material stability of the home and accept more egalitarian values in the U.S. (Adames & Campbell, 2005). In general, women experience quicker changes in gender role ideology than do men (Raj & Silverman, 2002). According to Flores et al. (2004), more acculturated Mexican husbands and wives experienced more direct marital conflicts than those less acculturated, either because they were more willing to openly express problems in their marriage or because they were involved in more direct struggles for power.

Against this backdrop, divorce/separation and increased argument between the partners may symbolize that Hispanic women gain more power to act independently or assert their point of view. Hispanic men may be reluctant to accept these new gender roles and power shifts, which are considered as a threat to their manhood and authority stemming from their primary role as economic and material providers in the home. Consequently, Hispanic men use physical assault as a means to sustain control over women even after separation (Adames & Campbell, 2005; Raj & Silverman, 2002).

Asians. Physical violence experience among Asian women included unwanted pregnancy by a husband/partner and imprisonment of self or husband in addition to direct physical fight and physical abuse. In general, a batterer is more likely to have control

over a victim's sexuality/life and engage in sexual risk-taking behaviors (e.g., unprotected sex), which elevates the risk of unwanted pregnancy (Coker, 2007). Reversely, women whose partner does not want the current pregnancy are at more than three times greater risk of being a victim of physical violence relative to their non-abused counterparts in the U.S. (Chu, Goodwin, & D'Angelo, 2010). These phenomena are also observed among Asian/Asian American populations. For example, physically abused Asian and Latina women were twice as likely as non-abused counterparts to experience unintended pregnancy (Cha, Masho, & Heh, 2016). Bangladesh women experiencing minor and severe physical violence reported having a 1.33 and 1.60-fold increased risk of unintended pregnancy, respectively, after adjusting for age, parity, education, religion, and past contraceptive use, relative to their non-abused counterparts. Possibly, fear of violence by their partner deprived women of their autonomy to regulate their fertility through negotiating use of contraception (Rahman, Sasagawa, Fujii, Tomizawa, & Makinoda, 2012). However, Asian cultures—patriarchal ideologies and rigid gender norms—may have also played a significant role in the distinct experience of victimized Asian women (Lee & Hadeed, 2009; Xu, Campbell, & Zhu, 2001). In Asian communities, men are valued and govern the family with great authority and power. One of the women's primary duties is to produce a son to extend the husband's patrilineage (Lee & Hadeed, 2009). Considering the culture of son preference, giving birth to a daughter is not desirable for women's husband or in-laws. Even, a failure to produce a son is considered as women's fault or even crime, which justifies her husband's physical acts (Xu et al., 2001).

The linkage between physical violence and imprisonment of self or husband may be explained in the context of premigration traumatic experience among Asian immigrant/refugee populations (e.g., Vietnamese, Chinese, and Cambodian). Such a traumatic experience encompasses war, political imprisonment, or genocide (Lee & Hadeed, 2009; Shiu-Thornton, Senturia, & Sullivan, 2005; Xu et al., 2001). Gupta et al. (2009) reported that immigrant men who were exposed to political violence (e.g., being detained, captured, or kidnapped) before arrival in the U.S. were about 2.7 times more likely to physically assault his wife/partner than their counterparts without experiencing political violence. Premigration trauma leads to IPV through mental health consequences, including posttraumatic stress disorder, depression, panic disorder, mental distress, or hopelessness (Gupta et al., 2009; Lee & Hadeed, 2009; Yoshioka & Dang, 2000). Additionally, Xu et al. (2001) documented that many Chinese immigrants/refugees have been traumatized by war or politics in China. The fear and mistrust of uniformed authorities make Chinese women reluctant to reporting IPV to the police, which perpetuates the abusive relationship with their husband.

Limitations

This study includes some limitations. First of all, a limited range of observed items of chronic stress has been used for analysis due to data availability. Chronic stress items in this study were only derived from external stressors, buffers of stress, and perceived stress. Despite the sufficient numbers of external stressors, buffers of stress had four items of social support, and perceived stress included only one item of race bias. Thus, the dimensionalities of chronic stress among the racial/ethnic groups may not

represent the complete scope of their chronic stress experiences before and during pregnancy.

Of note, race bias was represented by only one item and not correlated with any other items to form a latent factor even for racial/ethnic minority groups. As a result, race bias, despite its substantial influence on stress experience of racial/ethnic minority women, was not found as a component of their chronic stress. If race bias had been measured at multiple levels (e.g., individual, institutional, and cultural), underlying factors of chronic stress and their dynamics would have been different from those found in this study.

Also, the current dimensionalities of chronic stress could not capture nuanced stress experience among racial/ethnic minority women. For example, Rosenthal and Lobel (2011) documented three unique sources of stress among Black women, independent of financial, relationship, medical, and other sexism- and racism-related stressors: (1) history of abuse by the medical system; (2) contradictory social pressures on childbearing and motherhood; (3) stereotypical and degrading images regarding their sexuality and motherhood.

Lastly, this study analyzed four racial/ethnic populations only in NYC or WA because these two local PRAMS collected information about race bias and social support, which are essential to understand chronic stress experienced by racial/ethnic minorities. According to an intersectionality framework, regional location contributes to developing one's social identity, and in turn, determining their privilege and oppression (Bowleg, 2012). Chronic stress experience among women in NYC or WA is not guaranteed to be identical with that among women in other regions. Thus, generalization of the study

findings may be limited until the dimensionalities of chronic stress are confirmed in other populations.

Conclusion

The purpose of this study was to explore race/ethnicity-specific dimensionalities of chronic stress before and during pregnancy for N-H White, N-H Black, Hispanic, and Asian women. Although three out of four factors, including financial hardship, perceived isolation, and physical violence are chronic stressors that cut across four racial/ethnic groups, identities as non-White, female, or immigrant shape life conditions of racial/ethnic minority women where they have greater vulnerability to these chronic stressors prior to their childbirth. Further, chronic stress experience of each racial/ethnic group is under the influence of its own cultural norms and values.

Based on these findings, this paper concludes with the following suggestions for future research and practice to narrow the racial/ethnic disparities in adverse birth outcomes through a targeted approach to chronic stressors experienced by each racial/ethnic group of women. First, studies should be replicated in four racial/ethnic groups in other geographic locations with more comprehensive items of chronic stress before and during pregnancy to confirm the race/ethnicity-specific components of chronic stress. Importantly, future studies need to incorporate childhood adversity and items reflective of women's acculturation, including nativity and duration of U.S. residence for Hispanic and Asian women.

Second, based on the identified underlying factors of chronic stress, a new instrument of chronic stress could be developed, which reflects racial/ethnic distinctive

features. Its construct (convergent) validity can be examined by comparing the items with biomarkers of chronic stress, such as cardiovascular, metabolic, immune-inflammatory allostatic load mediators, hair cortisol, or microbiome. Discriminant validity also can be assessed by investigating if the new instrument successfully distinguishes itself from other chronic stress matrices (e.g., Perceived Stress Scale) to estimate health outcomes (e.g., chronic disease or adverse birth outcomes).

Third, culturally sensitive preventive strategies should be developed targeting specific racial/ethnic groups and chronic stressors. For instance, IPV risk assessment should be included in a regular care regimen for women, particularly racial/ethnic minority women in multiple settings, including clinical and community settings. Related institutions and agencies need to reach out to racial/ethnic minority communities to provide battered women with culturally and language sensitive services through which they can access to material, informational, and legal resources (Bauer et al., 2000; Hurwitz et al., 2006; Lee & Hadeed, 2009). Moreover, interventions to foster coping resources for Hispanic and Asian immigrant women should be developed and implemented to address their perceived isolation. Those interventions for socially isolated women can target enhancing social skills, providing social support, increasing opportunities for social interaction, or modifying over-attention or hypervigilance to negative social cues in the environment through a cognitive behavioral therapy (Hawkley & Cacioppo, 2010).

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Figure 1. Factor structure of chronic stress before and during pregnancy for (a) N-H White, (b) N-H Black, (c) Hispanic, (d) Asian women in NYC or WA (2004-2007)

Table 1.
Subject's Characteristics

Characteristic	N-H White (*n* = 2,314) %[a]	N-H Black (*n* = 1,476) %	Hispanic (*n* = 1,999) %	Asian (*n* = 1,061) %
Maternal education (years)				
0–8	0.42	1.83	12.72	3.22
9–11	7.25	14.10	23.07	8.66
12	22.90	30.93	32.39	23.32
13–15	27.56	30.83	19.35	18.08
≥16	41.88	22.31	12.47	46.72
Household income				
<$10,000	12.35	28.49	36.03	16.42
$10,000–$14,999	6.41	11.26	17.09	11.62
$15,000–$19,999	4.54	8.87	9.07	7.84
$20,000–$24,999	5.39	7.65	8.54	5.26
$25,000–$34,999	9.24	13.42	9.76	7.56
$35,000–$49,999	12.74	10.41	5.98	7.61
≥ $50,000	49.32	19.90	13.53	43.69
Health insurance before pregnancy				
Yes	73.71	58.17	41.98	67.77
No	26.29	41.83	58.02	32.23
Medicaid before pregnancy				
Yes	12.92	30.49	26.18	11.37
No	87.08	69.51	73.82	88.63
Affordability of prenatal care				
Yes	93.29	91.36	87.40	90.87
No	6.71	8.64	12.60	9.13
WIC during pregnancy				
Yes	28.34	65.17	77.08	36.56
No	71.66	34.83	22.92	63.44
Race bias				
Yes	2.93	13.67	12.46	10.69
No	97.07	86.33	87.54	89.31
Support – money				
Yes	92.68	86.51	82.25	65.40
No	7.32	13.49	17.75	34.60
Support – care				
Yes	93.84	88.75	85.28	83.29
No	6.16	11.25	14.72	16.71
Support – ride				
Yes	94.42	84.85	83.05	82.64
No	5.58	15.15	16.95	17.36
Support – talk				
Yes	93.94	90.02	84.45	84.07
No	6.06	9.98	15.55	15.93
Physical attack before pregnancy				
Yes	2.93	6.36	5.73	2.08
No	97.07	93.64	94.27	97.92
Physical attack during pregnancy				
Yes	2.07	5.47	4.87	0.90
No	97.93	94.53	95.13	99.10

Sick family member				
Yes	22.69	21.31	16.10	10.50
No	77.31	78.69	83.90	89.50
Separation/Divorce				
Yes	6.11	10.51	8.98	2.92
No	93.89	89.49	91.02	97.08
Move to a new address				
Yes	37.02	29.86	31.67	28.84
No	62.98	70.14	68.33	71.16
Homeless				
Yes	2.14	5.03	6.31	1.32
No	97.86	94.97	93.69	98.68
Husband/Partner lost job				
Yes	10.25	9.90	11.26	7.47
No	89.75	91.10	88.74	92.53
Mother lost job				
Yes	5.92	13.32	12.49	5.40
No	94.08	86.68	87.51	94.60
Argue lots				
Yes	19.27	37.60	24.93	16.84
No	80.73	62.40	75.07	83.16
Unwanted pregnancy				
Yes	6.44	12.42	9.93	3.83
No	93.56	87.58	90.07	96.17
Couldn't pay bill				
Yes	16.39	26.98	20.84	7.91
No	83.61	73.02	79.16	92.09
Physical fight				
Yes	2.23	6.62	3.66	1.48
No	97.77	93.38	96.34	98.52
Husband/Partner in jail				
Yes	2.89	3.74	3.16	1.12
No	97.11	96.26	96.84	98.88
Drinking or drug problems				
Yes	10.95	8.04	7.30	2.64
No	89.05	91.96	92.70	97.36
Others died				
Yes	13.26	17.93	16.78	6.89
No	86.74	82.07	83.22	93.11

Note. [a] Weighted percentage.

Table 2.
Items of Chronic Stress Before and During Pregnancy Identified in the NYC and WA PRAMS (2004–2007)

Variable name	Source	Question	Answer
Race bias	State-developed	During the 12 months before your new baby was born, did you feel emotionally upset (for example angry, sad, or frustrated) as a result of how you were treated based on your race?	Yes or no
Total household income	Core	During the 12 months before your new baby was born, what was your total household income before taxes?	o <$10,000 o $10,000–$14,999 o $15,000–$19,999 o $20,000–$24,999 o $25,000–$34,999 o $35,000–$49,999 o ≥ $50,000
Educational attainment	Birth certificate		0–8, 9–11, 12, 13–15, ≥16 years
Health insurance before pregnancy	Core	Just before you got pregnant, did you have health insurance? (Do not count Medicaid.)	Yes or no
Medicaid before pregnancy	Core	Just before you got pregnant, were you on Medicaid?	Yes or no
Unaffordable prenatal care	Core	I didn't have enough money or insurance to pay for getting prenatal care.	Yes or no
WIC during pregnancy	Core	During your most recent pregnancy, were you on WIC?	Yes or no
Physical abuse before pregnancy	Core	During the 12 months before you got pregnant, did an ex-husband or ex-partner push, hit, slap, kick, choke, or physically hurt you in any other way?	Yes or no
Physical abuse during pregnancy	Core	During your most recent pregnancy, did an ex-husband or ex-partner push, hit, slap, kick, choke, or physically hurt you in any other way?	Yes or no

Stressful life events	Core	This question is about things that may have happened during the 12 months before your new baby was born. 1) A close family member was very sick and had to go into the hospital. 2) I got separated or divorced from my husband or partner. 3) I moved to a new address. 4) I was homeless. 5) My husband or partner lost his job. 6) I lost my job even though I wanted to go on working. 7) I argued with my husband or partner more than usual. 8) My husband or partner said he didn't want me to be pregnant. 9) I had a lot of bills I couldn't pay. 10) I was in a physical fight. 11) I or my husband or partner went to jail. 12) Someone very close to me had a problem with drinking or drugs. 13) Someone very close to me died.	Yes or no
Social support	State-developed	During your most recent pregnancy, would you have had the kinds of help listed below if you needed them? 1) Someone to loan me $50 2) Someone to help me if I were sick and needed to be in bed 3) Someone to take me to the clinic or doctor's office if I needed a ride 4) Someone to talk with about my problems	Yes or no

Table 3.

Factor Loadings, Internal Consistency Reliabilities, and Variance Explained by Factors

	N-H White	N-H Black	Hispanic	N-H Asian
Factor 1	Can't pay bills Medicaid before pregnancy Maternal education Insurance before pregnancy WIC during pregnancy Household Income .44-.85[a], .65[b]	Insurance before pregnancy WIC during pregnancy Maternal education Household Income .45-.80, .71	Insurance before pregnancy Maternal education WIC during pregnancy Household Income .45-.68, .75	Insurance before pregnancy Maternal education WIC during pregnancy Household Income .56-.78, .83
Factor 2	Help for money ($50) Help for talk Help for ride Help for care when sick .45-.58, .77	Being in a physical fight Physical abuse before pregnancy Physical abuse during pregnancy .54-.72, .76	Help for money Help for talk Help for care when sick Help for ride .39-.49, .78	Help for money Help for care when sick Help for talk Help for ride .36-.65, .83
Factor 3	Being in a physical fight Physical abuse before pregnancy Physical abuse during pregnancy .43-.46, .70	Help for money Help for ride Help for talk Help for care when sick .47-.68, .74	Divorce/separation Physical abuse during pregnancy Physical abuse before pregnancy Increased argument with a partner .43-.48, .64	Physical abuse before pregnancy Unwanted pregnancy Being in a physical fight Imprisonment of self or husband .40-.67, .64
Total variance (variance explained by each factor)	80.1% (50.9, 16.5, and 12.7)	75.4% (35.3, 24.1, and 16.0)	76.1% (34.9, 21.5, and 19.7)	76.7% (37.1, 21.2, and 18.4)

Note. [a] A range of factor loadings; [b] Cronbach's alpha among items within a factor.

Table 4.

Intercorrelation among Chronic Stress Factors by Race/Ethnicity

Factor	1	2	3
N-H White			
1. Financial hardship	—	.28***	.27***
2. Perceived isolation		—	.23***
3. Physical violence			—
N-H Black			
1. Financial hardship	—	.09***	.24***
2. Physical violence		—	.07*
3. Perceived isolation			—
Hispanic			
1. Financial hardship	—	.15***	.09***
2. Perceived isolation		—	.11***
3. Physical violence			—
N-H Asian			
1. Financial hardship	—	.23***	.05
2. Perceived isolation		—	.07*
3. Physical violence			—

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

CHAPTER 4: PAPER 3

Chronic Stress and Preterm Birth: Testing the Moderating Effect of Maternal Age among Four Racial/Ethnic Groups

*Sangmi Kim, MPH, RN, sangmik@nursing.upenn.edu
**Eun-Ok Im, PhD, MPH, RN, CNS, FAAN, eun-ok.im@duke.edu
*Jianghong Liu, PhD, RN, FAAN, jhliu@nursing.upenn.edu
*Connie Ulrich, PhD, RN, FAAN, culrich@nursing.upenn.edu

Author Note

*University of Pennsylvania School of Nursing, Claire M. Fagin Hall
418 Curie Blvd., Philadelphia, PA 19104
**Duke University School of Nursing, 307 Trent Drive, Durham, NC 27710

Address for Correspondence:

Sangmi Kim, MPH, RN
Email: sangmik@nursing.upenn.edu / Phone: 484-821-7337

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Abstract

Objective: Maternal age trajectories of the chronic stress effect on preterm birth (PTB) have been less appreciated although stress may be cumulative over women's life-course. Also, heterogeneity of stress accumulation patterns is not clearly understood among racial/ethnic groups. This study aimed to explore the moderating effect of maternal age on the relationship between chronic stress and PTB by race/ethnicity.

Methods: This was a secondary analysis of the Pregnancy Risk Assessment Monitoring System data for Washington State (WA; 2004-2007) linked with birth certificates. The sample included 3,489 women aged between 18 and 49 years who were primigravid, gave birth to a live singleton birth without birth defects registered in WA, and self-identified as non-Hispanic (N-H) White, N-H Black, Hispanic, or Asian. An outcome variable was PTB. Predictor variables included maternal race/ethnicity, maternal age, chronic stress, and race bias. Covariates included marital status, chronic conditions, risky health behaviors, reproductive history, and pregnancy complications. Multivariate logistic regression was used within each racial/ethnic group to examine an interaction between maternal age and chronic stress and its racial/ethnic differences with covariates held constant. As a sub-analysis, alteration of the moderating effect of maternal age by race bias was investigated among racial/ethnic minority groups combined.

Result: A maternal age-related increase in PTB (weathering) was found among all racial/ethnic groups (except for Asians) only with high chronic stress before and during pregnancy. The increase was the steepest among N-H Whites (OR = 1.32 [1.29, 1.35]), followed by N-H Blacks (OR = 1.18 [1.10, 1.28]) and Hispanics (OR = 1.12 [1.08, 1.16]). Asian women rather showed a reverse weathering pattern even after controlling

for the covariates (OR = 0.94 [0.88, 1.00]). Experience of race bias amplified weathering for racial/ethnic minority women with high chronic stress (OR = 1.75 [1.64, 1.88]).

Conclusion: Despite variations in the magnitude, weathering was experienced among diverse racial/ethnic groups of women with high chronic stress. Acculturation stress should be further considered to ascertain the Asian women's maternal age pattern of PTB. Identification of chronic stressors and buffer systems unique to racial/ethnic subgroups could help reduce the excessive PTB risk of racial/ethnic minority groups of women.

Key Words: Weathering, Chronic Stress, Racism, Maternal Age, Racial/Ethnic Disparities, Preterm, PRAMS

Background

Despite numerous efforts for decades, the racial/ethnic gaps in preterm birth (PTB; < 37 weeks' gestation) have not been greatly narrowed in the United States. Black women are more likely than their White counterparts to experience PTB (18.3% vs. 11.5%; Giurgescu, McFarlin, Lomax, Craddock, & Albrecht, 2011). PTB increases the risk for infant morbidity (e.g., respiratory disorders, neurologic disorders, or neonatal intensive care unit admissions) and mortality (Engle, 2011). Also, PTB and its medical sequels pose enormous psychosocial and emotional burdens on the families including depressive symptoms and parenting stress (McCormick, Litt, Smith, & Zupancic, 2011; Saigal & Doyle, 2008). At a societal level, medical costs to treat PTB are quite considerable (Behrman & Stitch Butler, 2007). Thus, excess PTB risk among racial/ethnic minorities is surely a significant public health concern.

Although numerous contributors to PTB have been identified (e.g., maternal age, low socioeconomic status [SES], chronic conditions, risky health behaviors, and stress), they failed to exhaustively explain the racial/ethnic disparities in PTB; and, their mechanisms still remain unclear (Culhane & Elo, 2005; Giurgescu et al., 2011). This prompted a re-examination of the conventional model that tends to simply examine main effects only and overlook interactive relationships, for example, between biomedical and social factors (Giscombé & Lobel, 2005). One traditional risk factor that merits reconsideration is maternal age (Geronimus, 1996). In the existing literature, maternal age is assumed to be an entrenched biomedical indicator, independent of the effect of other social factors including race/ethnicity and only confounding the effect of race/ethnicity on adverse birth outcomes. For this reason, age-graded racial/ethnic gaps in

adverse birth outcomes have received little attention (Rich-Edwards, Buka, Brennan, & Earls, 2003). Geronimus and Snow (2013), however, asserted that women's health risk could be better appreciated and intervened by acknowledging variations in the age dimension of health by social conditions (e.g., gender or race/ethnicity) since social expectations, opportunities, and discriminations are age-graded and their health effects are often cumulative.

The weathering hypothesis first reported the divergent maternal age patterns of adverse birth outcomes between Black and White women, implicating an interaction between maternal age and race/ethnicity affecting fetal health (Geronimus, 1992). Weathering is defined as deterioration of health potential among Black women throughout the reproductive period that results from their exposure to chronic stress over the life course and the great effort to cope with stress (Geronimus, 1996; Geronimus et al., 2010). Specifically, the risk of adverse birth outcomes for Black women is the lowest in their teens (around 18-20 years old) and tends to steeply increase in their 20s. In contrast, the risk pattern is shifted for White women so that the risk is higher in their teens than in their 20s. In other words, Black women experience the best birth outcomes at earlier ages than do White women. As demonstrated by these two different maternal-age patterns, the Black–White gaps in adverse birth outcomes are compounded by maternal age (Geronimus, 1996). From the weathering perspective, maternal age does not just represent a mother's biological or psychosocial preparedness for childbearing (Geronimus, 1996). Instead, maternal age for underprivileged women (e.g., Black women) could be redefined as the duration of women's experience of or exposure to life-long stressful conditions (Borders, Grobman, Amsden, & Holl, 2007; Rich-Edwards et

al., 2003). By incorporating maternal age as not only biological but also psychosocial characteristic, the weathering framework helps interpret the life course progression in women's health, culminating into her birth outcomes (Geronimus et al., 2013).

Nevertheless, our understanding of weathering is limited for several reasons. First, although chronic stress has been suggested in theory to explain the increasing Black–White gaps in adverse birth outcomes by maternal age, efforts to empirically demonstrate the role of chronic stress in this phenomenon are lacking. Second, a conceptual ambiguity exists in assessing accumulation of stress although it has been operationalized as allostatic load or wear and tear of the body, which is technically the physiological reactions to prolonged exposure to stress (Juster, McEwen, & Lupien, 2010). The weathering hypothesis elucidates the race/ethnicity-maternal age relationship (i.e., race/ethnicity moderates the effect of maternal age), but it does not explain how chronic stress is associated with maternal age. If stress is cumulative over time, maternal age should be an integral part to represent the way chronic stress operates, and their relationship needs to be conceptually clarified for empirical tests (e.g., if maternal age moderates the effect of chronic stress). Third, the weathering framework has been mostly applied to Black women, although this perspective pertains to accumulated stress experienced by other racial/ethnic groups of women, such as Hispanics and Asians. Since the weathering hypothesis was proposed, some studies have tried to replicate Geronimus's work to directly examine weathering among racial/ethnic groups in diverse socioeconomic contexts and regions. However, most of their attention has been given to Black–White comparisons. Among them, evidence is even inconsistent on if weathering exists and which populations experience weathering: (a) weathering among Black women

as a single population (Buescher & Mittal, 2006; Sheeder, Lezottte, & Stevens-Simon, 2006); (b) a gradient of weathering within Black women according to the levels of neighborhood poverty (Collins, Jr., Simon, Jackson, & Drolet, 2006; Collins, Rankin, & Hibbs, 2015; Geronimus, 1996; Love, David, Rankin, & Collins, 2010); (c) weathering among women with unfavorable socioeconomic conditions or high-risk behaviors (e.g., smoking) regardless of race/ethnicity (Holzman et al., 2009; Rich-Edwards et al., 2003); (d) no weathering (Deal, Bennett, Rankin, & Collins Jr, 2014; Miranda et al., 2010). The current weathering research focused predominantly on Black women may limit opportunities to further investigate the significant role of chronic stress in weathering, which could be better understood through the experiences of Hispanic and Asian women. Indeed, Giscombé and Lobel (2005) argued that prenatal stress may have interactive effects with race/ethnicity that needs to be investigated.

Therefore, the purpose of this study is to explore the moderating effect of maternal age on the relationship between chronic stress and PTB among non-Hispanic (N-H) White, N-H Black, Hispanic, and Asian women. The hypothesis is that the effect of chronic stress on PTB is significantly different by both maternal age and race/ethnicity.

Methods

Different from Paper 2, only Pregnancy Risk Assessment Monitoring System (PRAMS) data for Washington State (WA) between 2004 and 2007 were used for analysis because New York City PRAMS did not collect birth order information, which was one of the key inclusion criteria in this study. Missing data (up to 41.5% depending on the variables) were imputed on the dependent and independent variables by using

regression method for continuous variables and logistic regression method for categorical variables since the data were assumed to have a monotone missing data pattern (Yuan, 2010). The purpose of multiple imputation in this study was to prevent loss of PTB cases especially among three racial/ethnic minority groups for more accurate estimation of their PTB risk, considering the small sample size of these populations. Although racial/ethnic minority groups were inclined to have more missing information than were N-H White women, this might not have generated biased study findings considering analyses were stratified by race/ethnicity. Results from a sensitivity test with the data prior to the multiple imputation generally agreed with the original findings for models unadjusted and adjusted for all covariates but drinking during pregnancy (41.5% of the missing information); producing stable estimates of the all parameters in the models was allowed only without the drinking variable. Among 3,626 women without missing information after multiple imputation, 59 subjects were excluded because they delivered newborn(s) that were second or third birth, twins+, or with birth defects. Additional 78 subjects were excluded because they were younger than 18 years. As a result, a total of 3,489 women were in analysis who aged 18 years or older and delivered first, singleton birth without birth defects in WA during the specified survey period (1,356 N-H Whites, 553 N-H Blacks, 900 Hispanics, and 680 Asians).

Dependent and Independent Variables

The outcome variable for this study was PTB, defined as gestational age less than 37 weeks. Predictor variables were race/ethnicity, maternal age, chronic stress, and race bias. Race/ethnicity was determined based on women's self-report of their race and Hispanic ethnicity. Four racial/ethnic groups, such as N-H White, N-H Black, Hispanic,

and N-H Asian were included in this study. Maternal age was initially coded in five groups (18–19, 20–24, 25–29, 30–34, 35+), and then measured on an ordinal scale ranging 1 to 5.

Chronic stress before and during pregnancy was measured based on the race/ethnicity-specific factor structures of chronic stress where the identified factors within each racial/ethnic group were summarized into one continuous mean score for individuals (refer Paper 2). Specifically, within each racial/ethnic group, the chronic stress items loaded to each factor were averaged for the subscale score (e.g., financial hardship, perceived isolation, and physical violence), and the subscale scores were averaged for the full-scale score: that is, the chronic stress index. Then, the chronic stress index was standardized, stratified by race/ethnicity, to create a z-score with a mean of zero and a standard deviation of one. This process enables the chronic stress index comparable across the racial/ethnic groups. The higher the index value was, the greater the level of chronic stress before and during pregnancy was. Chronic stress was dichotomized into higher and lower stress than average at a cut-off of zero.

Race bias was answered yes or no to the question “During the 12 months before your new baby was born, did you feel emotionally upset as a result of how you were treated based on your race?”

Covariates

The analysis incorporated maternal sociodemographic, medical, and behavioral characteristics, considered confounders or covariates in existing studies. Marital status was categorized as "married" and "others." Maternal chronic conditions included high

blood pressure (including pregnancy-induced hypertension, preeclampsia, or toxemia) during pregnancy (yes or no), diabetes before pregnancy (yes or no), gestational diabetes (yes or no), and prepregnancy body mass index (BMI; continuous). Health behaviors were measured by smoking during the last three months of pregnancy (yes or no), drinking during the last three months of pregnancy (yes or no), and prenatal care (PNC) received in the first trimester (yes, no, or no PNC). Reproductive history was categorized into five groups (no previous live birth, no LBW or PTB, previous LBW, previous PTB, or previous LBW and PTB). Pregnancy complications included if women had problems during pregnancy: Vaginal bleeding, urinary tract infection, severe nausea, vomiting, dehydration, cerclage for incompetent cervix, problems with the placenta, preterm or early labor, premature rupture of membrane, blood transfusion, or car accident. Initially, high blood pressure was a pregnancy complication question; instead, it was treated as a single independent covariate due to its great importance as a risk factor for adverse birth outcomes (Ødegård, Vatten, Nilsen, Salvesen, & Austgulen, 2000). Nine pregnancy complications without high blood pressure were summed for a score ranging from 0 to 9, categorized into 0, 1, 2, and 3 or more complications, due to the small proportion of women with more than three complications at the same time during pregnancy.

Statistical Analysis

Descriptive statistics of study participants were conducted for selected variables by race/ethnicity, using frequencies and proportions for categorical variables, and means for continuous variables. Chi-square test and t-test determined the statistical significance of the differences in participants' characteristics by race/ethnicity.

Logistic regression was conducted to examine the hypothesized moderating effect of maternal age on chronic stress to estimate PTB risk within each racial/ethnic group, unadjusted and adjusted for the covariates. The raw data were not over-dispersed, which was diagnosed with the Pearson Chi-square statistic and the deviance, divided by their degrees of freedom. First, a 3-way interaction (race/ethnicity x maternal age x chronic stress) alone was included in one model to examine its statistical significance. The interaction was tested not only with the raw data but with the sampled data (2 and 4 samples) that maintained the same PTB rate in the raw data to ensure that a significant 3-way interaction was not simply a product of a large sample size. The raw and sampled data demonstrated a significant 3-way interaction among the variables. Next, to better interpret the meaning of 3-way interaction, a 2-way interaction (maternal age x chronic stress) was examined in the model, stratified by race/ethnicity. Two models were built for each racial/ethnic group. Model 1 (null model) included maternal age, chronic stress, and their interaction term. Model 2 controlled for the race/ethnicity-specific risk factors for PTB to determine if a maternal age-chronic stress interaction still held with the same maternal features.

Moreover, for three racial/ethnic minority groups, relationships among maternal age, chronic stress, and race bias were examined through a stratified analysis where the interaction between maternal age and chronic stress was estimated according to race bias status. Race bias was not significantly correlated with other chronic stress items to generate an underlying factor; so that the effect of race bias was examined as a moderator. N-H White women were not incorporated in the analysis because their experience of race bias may differ from that of other racial/ethnic minority women in its

nature and meaning. Likewise, two models were established within each race bias group where Model 1 included maternal age, chronic stress, and their interaction term; Model 2 adjusted for predetermined maternal risk factors. The reason that only selected covariates were controlled for in Model 2 is that inclusion of all available maternal risk factors failed to estimate the maternal age-chronic stress interaction particularly among those with race bias due to their small PTB cases. Among the covariates mentioned above, hypertension during pregnancy, diabetes before and during pregnancy, smoking during pregnancy, PNC received in the first trimester, and pregnancy complications were chosen. Hypertension and diabetes have been acknowledged to be a manifestation of wear and tear on the bodily systems in the face of prolonged stress. Among three health behavior variables, drinking during pregnancy was excluded because a contribution of drinking to weathering was less understood, relative to smoking and PNC. Also, pregnancy complications were selected because they were thought to be more proximate risk factors of PTB.

This study had enough power (beta = 80%, alpha = 5%) to detect a risk difference if odds ratio (OR) was equal or greater than 1.6 with at least 480 observations for each racial/ethnic group (240 observations x 2 chronic stress groups). An OR of 1.6 was chosen because it was expected that subgroup analyses would demonstrate heterogeneity in effects, with older women under high chronic stress having higher odds of PTB. The significance of the interaction term was determined at $p < 0.05$. The PRAMS weight statement was included throughout the modeling process to account for sample selection and responses and to reflect the population of mothers delivering live births in WA during the 2004–2007 survey periods. Considering each group of N-H Black,

Hispanic, and Asian women have different sampling rates than the other groups in the PRAMS data, the analysis weight for the entire population is allowed to applied in each racial/ethnic group and in logistic regression modeling as well (B. Morrow, personal communication, June 9, 2017). All analyses were conducted using SAS Version 9.4 statistical software (SAS Institute, Inc., Cary, NC). This study was exempt from IRB approval.

Results

Table 1 shows subjects' characteristics by race/ethnicity. While over 50% of N-H Black and Hispanic women delivered the first birth in their 20s, N-H White and Asian women postponed childbearing to the later point. In particular, approximately 60% of Asian women gave their first birth when they were 30+ years old. For chronic stress, over half of the N-H Black and Hispanic women experienced higher stress whereas more N-H White and Asian women experienced lower stress. The prevalence of race bias was greatest among N-H Black women, followed by Hispanic and Asian women. As to chronic conditions, N-H White and N-H Black women were as twice more likely to be hypertensive during pregnancy as Hispanic and Asian women. In contrast, the prevalence of diabetes during pregnancy among Hispanic and Asian women was 1.5-2 times higher than the prevalence among N-H White and N-H Black women. For health behaviors, the prevalence of smoking during pregnancy among N-H White and N-H Black women was 2-3 times greater than the prevalence among Hispanic and Asian women. The prevalence of not receiving early PNC was highest among Hispanic women, but the prevalence of no PNC at all was highest among Asian women.

Table 2 shows PTB rates by maternal characteristics and race/ethnicity. Maternal risk factors of PTB were found to be race/ethnicity-specific. For example, marital status and prepregnancy BMI for N-H White, prepregnancy BMI and drinking for N-H Black, prepregnancy BMI for Hispanic, and prepregnancy BMI and drinking for Asian women were not associated with PTB; such that these risk factors were not included in the subsequent analysis.

Moderating Effect of Maternal Age on Chronic Stress-PTB Association by Race/Ethnicity

In unadjusted models, a maternal age-chronic stress interaction was statistically significant for four racial/ethnic groups. Among all groups but Asians, those under higher stress showed a maternal age-related increase in PTB (i.e., weathering) while their lower stress counterparts presented the opposite pattern (the decrease was not significant only among N-H Blacks). Unlike these three racial/ethnic groups, a PTB risk among Asian women under higher stress rather decreased at advancing maternal age (OR = 0.85, 95% CI = 0.81-0.90) while such a risk increased with maternal age among their lower stress counterparts (OR = 1.08, 95% CI = 1.02-1.16) (see Table 3 & Figure 1-4).

In full models after controlling for the race/ethnicity-specific maternal risk factors, the maternal age patterns of PTB risk remained the same with those in the unadjusted models; the maternal age-chronic stress interaction was statistically significant for all groups. With the same maternal characteristics, a maternal age-related increase in PTB risk among a higher stress group was the steepest among N-H White, followed by N-H Black and Hispanic women. Although Asian women under higher stress

still showed a maternal age-related decrease in PTB risk, a decreasing rate was reduced to the point not clinically meaningful when maternal risk factors were held constant (OR = 0.94, 95% CI = 0.88-1.00). A specificity test showed the identical patterns between the raw and predicted values.

Moderating Effect of Race Bias on Maternal Age-Chronic Stress Interaction

In unadjusted models, a maternal age-chronic stress interaction among racial/ethnic minority women (N-H Blacks, Hispanics, and Asians) was different by race bias status. Specifically, within those who experienced race bias, a higher stress group showed a substantial increase in PTB risk with maternal age (OR = 1.56, 95% CI = 1.46-1.66) whereas a lower stress group presented a maternal age-related decrease in the risk (OR = 0.29, 95% CI = 0.23-0.36; see Table 4). Within those without race bias, however, no significant maternal age-chronic stress interaction was found (p = 0.5205; see Table 4). While a higher stress group was more likely than a lower stress group to deliver PTB across maternal age, both stress groups did not show a significant change in PTB risk according to maternal age. It is worth noting that experience of race bias accelerated the increase in PTB risk with maternal age within a higher stress group (see Figure 5).

In full models after controlling for the predetermined maternal risk factors, the maternal age patterns of PTB risk remained the same for all race bias-chronic stress combinations (see Table 4). A maternal age-chronic stress interaction was significant only among those with race bias. Within a race bias group, even a maternal age-related increase in PTB risk among a higher stress group was amplified with maternal risk

factors held constant (OR = 1.75, 95% CI = 1.64-1.88). A specificity test also showed the accordance in patterns between the raw and predicted values.

Discussion

As hypothesized, the effect of chronic stress on PTB was moderated by maternal age within racial/ethnic groups: only women with high chronic stress experienced a maternal age-related increase in PTB in N-H White, N-H Black, and Hispanic communities although their Asian counterparts showed the opposite pattern. Racial/ethnic differences were found in the extent of increasing rate of PTB with maternal aging. Besides, the experience of race bias amplified a moderating effect of maternal age on the chronic stress-PTB association among racial/ethnic minority women altogether, manifested as the steepest maternal age-related increase in PTB among those with a high chronic stress burden and race bias.

Weathering of N-H White and N-H Black Women

As mentioned earlier, since weathering was first observed in the 1990s, this phenomenon has been documented mostly among Black women. Regardless of unfavorable socioeconomic, behavioral, or biomedical conditions, White women were found not to experience weathering in several studies (Buescher & Mittal, 2006; Collins et al., 2015; Geronimus, 1996; Hibbs, Rankin, David, & Collins, 2016; Love et al., 2010; Rauh, Andrews, & Garfinkel, 2001; Sheeder et al., 2006). For example, Hibbs et al. (2016) reported a maternal age-related increase in PTB only among Black smokers with an early-life during infancy or life-long residence in lower income neighborhoods while White women did not show weathering, regardless of their smoking status and life-long residence in lower income neighborhoods.

In contrast, some argued that women in disadvantaged life conditions, regardless of race/ethnicity, experienced weather-away of their health. Rich-Edwards et al. (2003) documented that both Black and White women in Chicago presented weathering about LBW when they were unmarried, living in poor neighborhoods, smoking cigarettes, or receiving inadequate PNC. Similarly, Holzman et al. (2009) reported a greater PTB risk among older Black and White women who were smokers living in high deprivation areas. Cerda, Buka, and Rich-Edwards (2008) echoed these findings by noting the steeper decline in birth weight with advancing maternal age among mothers who resided in more disadvantaged neighborhoods (e.g., the proportion of residents living below the poverty line, on public assistance, and unemployed) when race/ethnicity (e.g., Black, White, Hispanic, and other) was controlled for. Although these studies did not investigate the direct chronic stress-birth outcome relationships, the moderating factors used (e.g., neighborhood poverty and smoking) are robust proxies for chronic stress (Stapleton et al., 2015; Strutz et al., 2014). Residence in highly deprived neighborhoods may be associated with chronic exposure to stressful social conditions as well as reduced access to opportunities for social engagement that might mitigate such environmental stress (Cerda et al., 2008; Hibbs et al., 2016). Also, people may adopt or reinforce unhealthy behavioral coping mechanisms, such as smoking to deal with their prolonged stress (Gavin, Nurius, & Logan-Greene, 2012; Myers, 2009). The differing findings of Hibbs et al. (2016) regarding weathering of White women, despite the same moderating effectors (e.g., neighborhood poverty and smoking), may be attributed to differences in data, sample populations, covariates, or neighborhood measures.

The current findings also agree with the existing literature reporting that not all, but only the disadvantaged Black women are subject to weathering. For example, several studies documented a gradient of weathering with regard to LBW, PTB, or small for gestational age (SGA; birth weight below the 10th percentile for the gestational age) among Black mothers according to their neighborhood poverty assessed by life-long or one point median/mean family income in the neighborhood. That said, an increase in the adverse birth outcomes was accelerated with maternal age among those living in the poorer neighborhood (Collins et al., 2015; Geronimus, 1996; Love et al., 2010). No weathering, however, was observed at all among Black mothers in the affluent neighborhood. These studies suggested that neighborhood poverty results in adverse birth outcomes through psychosocial stressors, such as lower purchasing power, perceived or actual racial discrimination, token stress, or role overload (Collins et al., 2015; Geronimus, 1996; Love et al., 2010). Such a psychosocial pathway was corroborated by the current study where N-H Black women only with high chronic stress experienced a maternal age-related increase in PTB.

Relative to N-H White women, the weaker weathering among N-H Black women may be because race bias was considered in separation from chronic stress. Interpersonal or institutional racism has been acknowledged as a chronic stress experience pervasive in the lives of racial/ethnic minority women (Dominguez, 2008; Dunkel Schetter, 2011; Dunkel Schetter et al., 2013; Dunkel Schetter & Tanner, 2012; Guendelman, Lang Kosa, Pearl, Graham, & Kharrazi, 2008; Latendresse, 2009; Rich-Edwards & Grizzard, 2005; Rich- Edwards et al., 2001). Thus, weathering among N-H Black women was likely to be underestimated to some degree (Giscombé & Lobel, 2005).

Weathering among Hispanic Women

This study adds to the limited evidence of weathering among Hispanic women (Collins, Rankin, & Hedstrom, 2012; de Jongh, Locke, Paul, & Hoffman, 2012; Dennis & Mollborn, 2013; Khoshnood, Wall, & Lee, 2005; Miranda et al., 2010; Powers, 2013; Sheeder et al., 2006; Wildsmith, 2002). Notably, it may be the first study to identify a different maternal age pattern of PTB within the group according to the levels of chronic stress. Consistent with the current findings, Khoshnood et al. (2005) found a maternal age-related increase in very LBW (VLBW; birth weight < 1,500g), moderately LBW (MLBW; 1,500g ≤ birth weight < 2,500g), and LBW for N-H Black, Mexican, and Puerto Rican women, whose risk differences between 20-34 and 35+ years of maternal age were the highest among N-H Black women, followed by Puerto Rican and Mexican women. Powers (2013) also documented that older Mexican-origin mothers were more likely to experience infant mortality than their N-H White counterparts while younger Mexican-origin mothers enjoyed lower infant mortality than younger N-H White mothers (known as the Hispanic paradox). When stratified by nativity, however, a difference in the maternal age pattern of infant mortality was not significant between Mexican Americans and Mexican immigrants although the former exhibited higher infant mortality across maternal age than did the latter. Considering a longer exposure to U.S. social conditions among Mexican Americans than Mexican immigrants, infant mortality gaps between the groups were expected to incline with maternal age. It is acknowledged that stress resulting from the process of acculturation and racial/language discrimination undermines the health of foreign-born Hispanic women and across generations, implying

a greater cumulative stress among those with a longer period lived in the U.S. (Powers, 2013).

It is possible that heterogeneity of the population in terms of acculturation or duration of U.S. residence may have masked weathering among Mexican Americans, which was not considered in the study due to data availability. Acculturation stress (e.g., English as a second language and foreign-born status) is a unique source of chronic stress among immigrant populations (Hobel, Goldstein, & Barrett, 2008; Strutz et al., 2014). This study assumed that maternal age represented a length of time in the U.S. However, maternal age alone without the acculturation stress variables may not quite capture cumulative stress experienced by Mexican Americans over the life course. It is true that the current study also could not avail information on acculturation status, nativity, or duration of U.S. residence of Hispanic women. Nevertheless, the cumulative stress measure (i.e., chronic stress index) with a broad range of chronic stress variables may have offered enough power to identify the present differences in maternal age-specific PTB risk among Hispanic women with high chronic stress.

In contrast, Collins, Rankin, and Hedstrom (2012) observed a downward trend in LBW, PTB, and intrauterine growth retardation with maternal age among US-born urban Mexican American mothers even with a lifelong residence in neighborhoods in the lower half of the income distribution. Although established (second generation or above) US-born Mexican Americans had modestly greater rates of the adverse birth outcomes than first generation US-born Mexican Americans, no significant differential in the maternal age patterns was found between the groups. The decreasing adverse birth risks with

maternal age among those living in the deprived neighborhoods may be because disadvantaged Mexican American mothers, more vulnerable to exposure to chronic stress, were not properly captured by the study's measure of lifelong neighborhood poverty, and accordingly, failed to reveal the possible weathering among established US-born Mexican Americans. Indeed, only 1.0% and 2.9% of first and established US-born Mexican Americans, respectively, resided in the impoverished urban neighborhoods (e.g., quartile 1 of the income distribution) with a concentration of a larger percentage of Black women.

Weathering among Asian Women

To my knowledge, only a couple of studies exist to examine maternal age patterns of adverse birth outcomes among Asian women. Historically, attempts to apply the weathering framework to Asian women have been precluded mostly due to their small sample size in the collected data (Love et al., 2010; Reagan & Salsberry, 2005). Different from the current findings, the existing evidence, albeit a little, reported an indirect or direct indication of weathering in this population. Penfield, Cheng, and Caughey (2013) observed lower odds of several obstetric complications—PTB, primary cesarean delivery, and gestational diabetes—among Asian adolescents in comparison with their N-H White counterparts. According to the weathering hypothesis, the age of best reproductive health is younger for women with a greater stress burden throughout their lives (Geronimus, 2003). Moreover, Kim (2016) compared a maternal age trajectory of LBW between Asian and N-H White women across 13 U.S. states. The author found a general upward trend of LBW with maternal age after controlling for not only maternal risk factors but also their two- and three-way interactions (e.g., maternal age x risk factors and

race/ethnicity x maternal age x risk factors [diabetes before pregnancy, gestational diabetes, and smoking]).

As mentioned above, one possible reason for a reverse weathering among Asian women with high chronic stress may be that such key variables not considered in this study as acculturation status, nativity, and duration of U.S. residence may have confounded the chronic stress-maternal age-PTB relationship in this population. Indeed, a similar maternal age pattern was observed among Mexican-American women who had lived in poor neighborhoods over the life course when acculturation or chronic stress was not taken into account (Collins et al., 2012). In addition, we cannot rule out a response bias derived from the tendency toward underreporting stigmatizing, embarrassing, or highly valued problems among Hispanic and Asian women (Gallo, Jiménez, Shivpuri, De Los Monteros, & Mills, 2011; Tourangeau & Yan, 2007). Chronic stress measures used in this study pertained to many sensitive topics, including physical violence, unwanted pregnancy, and imprisonment. Such a bias could have dampened the magnitude of weathering experienced among Hispanic women and even distorted a real picture of weathering among Asian women especially when a sample size is not large. Lastly, Asian's unique cultural attitudes toward stress may have played a significant role in their stress coping or resilience. Immigration experience among Asian American women is considered as not only a source of trauma but also an enhancer of resilience (Reyes & Constantino, 2016). Asian American women tend to conceptualize resilience as perseverance, withstanding, and endurance (Reyes & Constantino, 2016). Overcoming adversities are viewed as one's internal strength, greatly respected by others in Asian communities (Im, Liu, Kim, & Chee, 2008). Such attitudes or beliefs may have nurtured

capacity of Asian women to better function in the face of chronic stress, which requires further research.

Role of Race Bias in Chronic Stress-PTB Relationship

This study found that race bias as a moderator exacerbated a maternal age-related increase in PTB within racial/ethnic minority women under higher chronic stress. Giscombé and Lobel (2005) argued that racism could be conceptualized as a distinct form of stress, independent of other types of stress, which exerts a direct impact on reproductive outcomes because racial discrimination involves stimuli (actions, events, or practices executed by individuals and organizations) that are appraised as stressful and that produce negative emotional responses. Dole et al. (2003) supported this notion by reporting a 40% greater risk of spontaneous PTB among women in the higher racial discrimination group than those in no racial discrimination group, above and beyond the effect of other stress measures (e.g., stressful life events and psychological distress). Along the same line, Osypuk and Acevedo-Garcia (2008) documented a steeper increase in PTB with maternal age among Black women in the hyper-segregated area where they encounter such stressors as worse treatment when renting an apartment or buying a house.

However, it is questionable why weathering was not observed anymore among racial/ethnic minority women with higher chronic stress when they did not experience race bias; why those with race bias and lower chronic stress showed a considerable decrease in PTB risk with maternal age. Two explanations are possible to interpret this unclear interactive relationship among race bias, chronic stress, and maternal age. First,

these results could be an artifact of a small number of PTB cases for both stress groups who experienced race bias. Within those with race bias, only 26 and 7 PTBs, respectively, occurred among the higher and lower stress group while 125 and 100 PTB cases were reported among their counterparts without race bias. 26 and 7 PTB events, despite being weighted, may not have enough power to produce precise estimates of PTB risk for each stress group.

Second, an inclusion of Asian women in the analysis could have confounded the effect of race bias on the association between maternal age and PTB, particularly among a higher stress group. Different from N-H Black and Hispanic women, Asian women with higher stress exhibited a reverse weathering pattern (decrease in the PTB risk at advancing maternal age). By clumping the heterogeneous populations into one as non-White minority women, their opposite maternal age patterns of PTB risk among a higher stress group could have canceled out the cumulative effect of maternal age on PTB, in particular among those without race bias who were the majority of women with higher stress. Indeed, when the same analysis was conducted without Asian women, N-H Black and Hispanic women with higher stress and no race bias experienced a maternal age-related increase in PTB risk (OR = 1.07, 95% CI = 1.04-1.11), which was not observed in the previous analysis. N-H Black and Hispanic women with higher stress and race bias showed a steeper maternal age-related increase in PTB risk than their no race bias counterparts (OR = 1.70, 95% CI = 1.58-1.83), indicating a gradient of weathering by race bias status among those under higher stress.

Strengths and Limitations

This study has certain limitations. First, it was limited in the operational definition of chronic stress due to data availability. For example, childhood adversity and acculturation stress could not be analyzed, despite their contribution to chronic stress experiences among racial/ethnic minority women. Nevertheless, a composite index of chronic stress was derived from the comprehensive proxy variables for chronic stress across domains (e.g., external stressors and buffers of stress), most importantly specific to each racial/ethnic group. Such a cumulative stress measure by using latent variables is useful not only to represent a complex construct of stress but also improve power to detect the stress-birth outcome relationships (Dole et al., 2003; Giscombé & Lobel, 2005). Second, only four racial/ethnic groups of women whose birth was registered in WA were included in the analysis because only WA PRAMS collected women's information on race bias, social support, and birth order between 2004 and 2007. As a result, it may be difficult to generalize the study findings to four racial/ethnic groups in other regions. Third, given the cross-sectional design, observed associations between chronic stress and PTB were likely to be bidirectional (Gallo et al., 2014). Although women's chronic stress could lead to PTB, those who delivered PTB may also experience increased stress or over-report their stress. Thus, a PTB event could contribute to a reverse causation bias that inflates observed effect of chronic stress.

Despite these limitations, this study helped elucidate the chronic stress mechanisms of weathering with regard to PTB that varied by each racial/ethnic group through developing a race/ethnicity-specific cumulative measure of chronic stress and empirically testing multiple interactive relationships among the key risk factors (e.g.,

chronic stress, maternal age, and race bias) stratified by race/ethnicity. Further, this study contributed to making a theoretical ground firm to expand the weathering framework to other disadvantaged women in chronically stressful circumstances, which could facilitate a life-course approach to women's health.

Conclusion

In summary, chronic stress may be a universal mechanism of weathering across race/ethnicity with variations in stress experience among racial/ethnic groups before and during pregnancy. Accumulation of stress indicates the greater impact of stress on adverse birth outcomes among older women with a high stress burden. The extent of accelerated aging in response to chronic stress differs by race/ethnicity.

To address the racial/ethnic differentials in chronic stress effects across maternal age, future research should replicate the study among other four racial/ethnic groups with more comprehensive chronic stressors that span the whole four domains, including external stressors, buffers of stress, enhancers of stress, and perceived stress. Especially, nativity, duration of U.S. residence, strong family ties, levels of acculturation, or cultural identity should be considered for Hispanic and Asian women most of whom are foreign-born to better assess their chronic stress in relation with other risk factors, such as racism. A conceptual model of weathering can be clarified by testing if acculturation may mitigate or exacerbate effects of chronic stress and racism on adverse birth outcomes within each racial/ethnic minority group (Giscombé & Lobel, 2005).

Another issue worth consideration is that biological differences in response to chronic stress may underlie the identified racial/ethnic variations in weathering with

regard to PTB. It is possible that not only chronic stressors but also biomarkers are not universal among different racial/ethnic groups (Menon, 2009). The identification of a race/ethnicity-specific biological mediator between chronic stress and PTB may ultimately help develop novel therapies to prevent PTB based on personalized risk assessment using a multitude of factors (e.g., biological and psychosocial factors) associated with a given individual (Menon, 2009; Rich- Edwards et al., 2001).

Screening for chronic stress is essential in clinical settings to provide further detail about sources of chronic stress and allow health providers to investigate further, counsel for healthy behaviors during pregnancy, and refer to other resources as needed (Wilson, Dyer, Latendresse, Wong, & Baksh, 2015). The American College of Obstetricians and Gynecologists suggested including psychosocial assessment in every trimester as part of standard care for all expectant mothers (Hobel et al., 2008). Development of risk algorithms for chronic stress distinctive to racial/ethnic groups can be used to recognize and assess chronic stress as well as take a targeted approach to intervene with pregnant women.

In addition to identifying stressors, it is necessary to understand coping in various racial/ethnic groups of women. Dunkel Schetter (2011) proposed exploratory works to determine what methods pregnant women of particular race/ethnicity use to manage stress in their lives and what works or does not work for them. Moreover, exploring cultural attitudes, beliefs, or values of chronic stress and resilience underlying the practices among racial/ethnic groups of pregnant women to handle their prolonged stress may be another promising avenue to understand exactly which types and sources of

support are relevant for each racial/ethnic subgroup and address the appropriateness of existing stress management interventions (e.g., physical relaxation and meditation, assessment and education, and counseling and social support) for improving birth outcomes in specific racial/ethnic subgroups (Dunkel Schetter, 2011; Hobel et al., 2008).

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Table 1.
Distribution of Maternal Characteristics by Race/Ethnicity

Characteristic	N-H White (*n* = 1,356)	N-H Black (*n* = 553)	Hispanic (*n* = 900)	Asian (*n* = 680)	Total (*n* = 3,489)
Preterm birth (%[a])					
Yes	10.31	15.29	10.55	11.64	10.62
No	89.69	84.71	89.45	88.36	89.38
Maternal age (%)					
18-19	6.24	8.08	8.48	3.17	6.41
20-24	20.48	27.43	32.25	14.08	22.13
25-29	28.74	31.55	28.81	25.61	28.58
30-34	28.71	17.83	18.48	36.15	27.28
35+	15.83	15.10	11.98	20.99	15.60
Chronic stress (%)					
Higher stress	37.97	56.97	63.44	38.07	42.85
Lower stress	62.03	43.03	36.56	61.93	57.15
Race bias (%)					
Yes	2.67	14.26	11.90	10.01	5.22
No	97.33	85.74	88.10	89.99	94.78
Marital status (%)					
Married	76.49	46.41	56.37	82.62	72.67
Other	23.51	53.59	43.63	17.38	27.33
Hypertension during pregnancy (%)					
Yes	12.64	15.18	6.60	6.11	11.16
No	87.36	84.82	93.40	93.89	88.84
Diabetes before pregnancy (%)					
Yes	1.45	2.68	2.45	1.97	1.70
No	98.55	97.32	97.55	98.03	98.30
Diabetes during pregnancy (%)					
Yes	8.18	7.86	12.56	14.94	9.48
No	91.82	92.14	87.44	85.06	90.52
Prepregnancy BMI (mean[b])	25.52	27.04	26.23	22.86	25.46
Smoking (%)					

Yes	12.10	10.21	4.19	5.68	10.17
No	87.90	89.79	95.81	94.32	89.83
Drinking (%)					
Yes	16.39	13.16	15.22	20.03	16.40
No	83.61	86.84	84.78	79.97	83.60
Prenatal care in the 1st trimester (%)					
Yes	84.23	78.27	75.92	79.76	82.26
No	15.43	21.03	23.60	18.31	17.23
Not at all	0.34	0.70	0.48	1.93	0.51
Reproductive history (%)					
No previous live birth	44.04	39.79	31.78	49.94	42.36
Not LBW or PTB	49.31	48.34	54.08	39.67	49.25
LBW	1.86	4.61	7.40	3.90	3.05
PTB	2.28	3.20	2.97	4.18	2.59
LBW & PTB	2.51	4.06	3.77	2.32	2.75
Pregnancy complications (%)					
0	46.44	43.54	43.41	54.52	46.53
1	29.07	30.46	29.90	30.90	29.41
2	16.23	14.30	16.91	9.83	15.74
3+	8.26	11.70	9.77	4.75	8.33

Note. [a] Weighted percentage; [b] Weighted mean.

Table 2.
Prevalence[a] of PTB by Maternal Characteristics and Race/Ethnicity[b]

Characteristic	N-H White (n = 1,356)	N-H Black (n = 553)	Hispanic (n = 900)	Asian (n = 680)	Total (n = 3,489)
Maternal age					
18-19	5.64	9.27	17.01	17.45	8.80
20-24	11.37	15.51	8.91	11.17	10.93
25-29	10.09	15.90	10.36	11.56	10.46
30-34	10.78	14.39	6.27	13.04	10.60
35+	10.32	17.89	17.41	8.77	11.29
Chronic stress					
Higher stress	10.61	17.08	11.87	13.13	11.39
Lower stress	10.12	12.92	8.25	10.73	10.05
Race bias					
Yes	12.65	18.28	**10.31**[c]	**11.83**[c]	12.13
No	10.24	14.79	**10.58**[c]	**11.62**[c]	10.54
Marital status					
Married	**10.34**[c]	12.07	10.02	11.21	10.42
Other	**10.19**[c]	18.07	11.23	13.70	11.16
Hypertension during pregnancy					
Yes	12.82	23.42	16.85	18.97	13.98
No	9.94	13.83	10.10	11.16	10.20
Diabetes before pregnancy					
Yes	31.54	32.53	20.96	23.39	28.23
No	10.00	14.81	10.28	11.40	10.32
Diabetes during pregnancy					
Yes	16.47	28.20	8.41	13.38	14.19

No	9.76	14.19	10.85	11.86	10.25
Smoking					
Yes	10.76	10.07	6.54	15.85	**10.69[c]**
No	10.25	15.88	10.72	11.39	**10.62[c]**
Drinking					
Yes	8.73	**14.14[c]**	13.83	**11.65[c]**	9.97
No	10.62	**15.46[c]**	9.96	**11.64[c]**	10.75
Prenatal care in the 1st trimester					
Yes	10.10	15.35	8.99	10.73	10.14
No	11.07	14.55	15.76	15.09	12.65
Not at all	27.96	30.38	0.00	16.64	20.04
Reproductive history					
No previous live birth	11.76	13.04	9.15	11.79	11.47
Not LBW or PTB	8.62	13.24	10.16	10.02	9.15
LBW	8.33	23.82	8.97	10.33	9.57
PTB	12.18	48.27	18.49	28.44	17.08
LBW & PTB	17.71	26.05	24.76	8.15	19.04
Pregnancy complications					
0	7.40	10.78	8.90	10.29	8.03
1	7.70	12.41	11.09	11.84	8.80
2	17.88	16.35	10.03	10.22	16.02
3+	20.95	38.27	17.09	28.82	21.37

Note. [a] Weighted percentage; [b] A *p* value of a chi-square test for each risk factor within racial/ethnic groups was <. 0001 except for some factors, such as marital status among N-H White, drinking among N-H Black, race bias among Hispanic, and race bias and drinking among Asian women. Also, a t-test for prepregnancy BMI did not achieve statistical significance at the alpha level of 5% (data not shown); [c] A chi-square test did not achieve statistical significance at the alpha level of 5%.

Table 3.

Odds Ratio of PTB for Maternal Age by the Level of Chronic Stress, Unadjusted and Adjusted for Maternal Risk Factors

	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)
N-H White		
Higher stress	1.23 (1.21, 1.26)	1.32 (1.29, 1.35)
Lower stress	0.93 (0.91, 0.95)	0.97 (0.95, 0.99)
p value[b]	<.0001	<.0001
N-H Black		
Higher stress	1.25 (1.17, 1.33)	1.18 (1.10, 1.28)
Lower stress	0.95 (0.86, 1.04)	0.95 (0.86, 1.05)
p value	<.0001	0.0004
Hispanic		
Higher stress	1.14 (1.10, 1.18)	1.12 (1.08, 1.16)
Lower stress	0.83 (0.79, 0.88)	0.86 (0.81, 0.90)
p value	<.0001	<.0001
Asian		
Higher stress	0.85 (0.81, 0.90)	0.94 (0.88, 1.00)
Lower stress	1.08 (1.02, 1.16)	1.07 (1.00, 1.14)
p value	<.0001	0.0039

Note. PTB = preterm birth; OR = odds ratio; CI = confidence interval.

[a] Adjusted for the race/ethnicity-specific covariates. Among all available covariates, marital status and prepregnancy BMI among N-H White, drinking and prepregnancy BMI among N-H Black, prepregnancy BMI among Hispanic, and drinking and prepregnancy BMI among Asian women were not included in the model (See Table 2).

[b] A *p* value for a maternal age-chronic stress interaction (lower stress group as a reference).

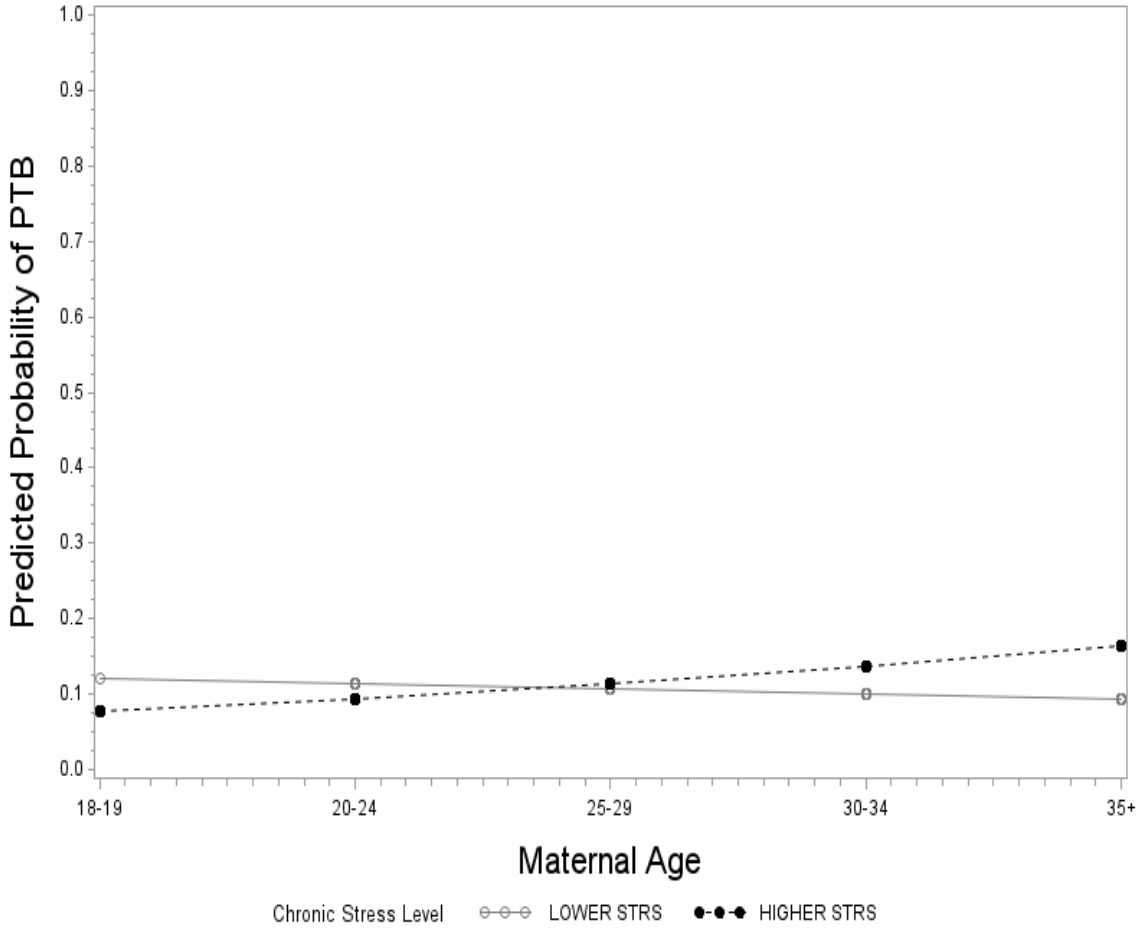

Figure 1. Unadjusted predicted probability of PTB by maternal age and chronic stress among N-H Whites

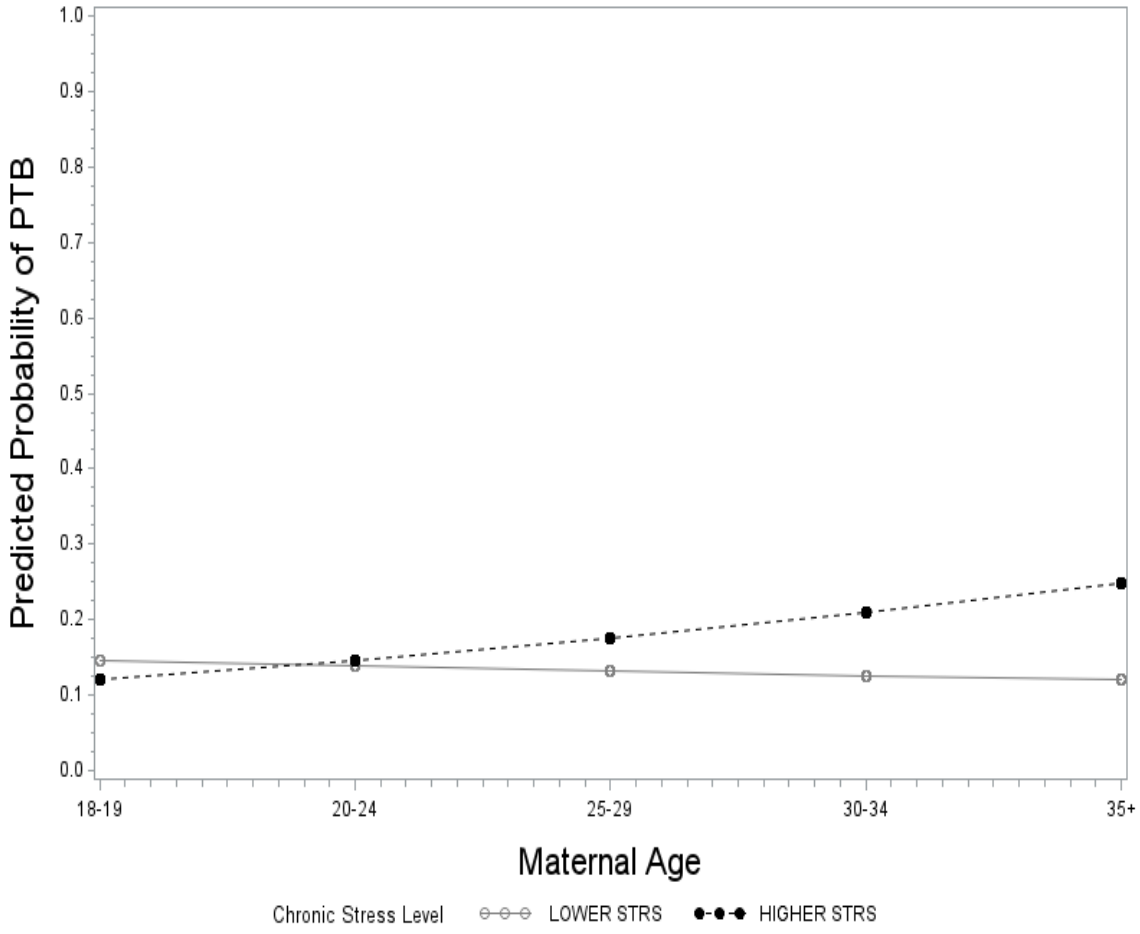

Figure 2. Unadjusted predicted probability of PTB by maternal age and chronic stress among N-H Blacks

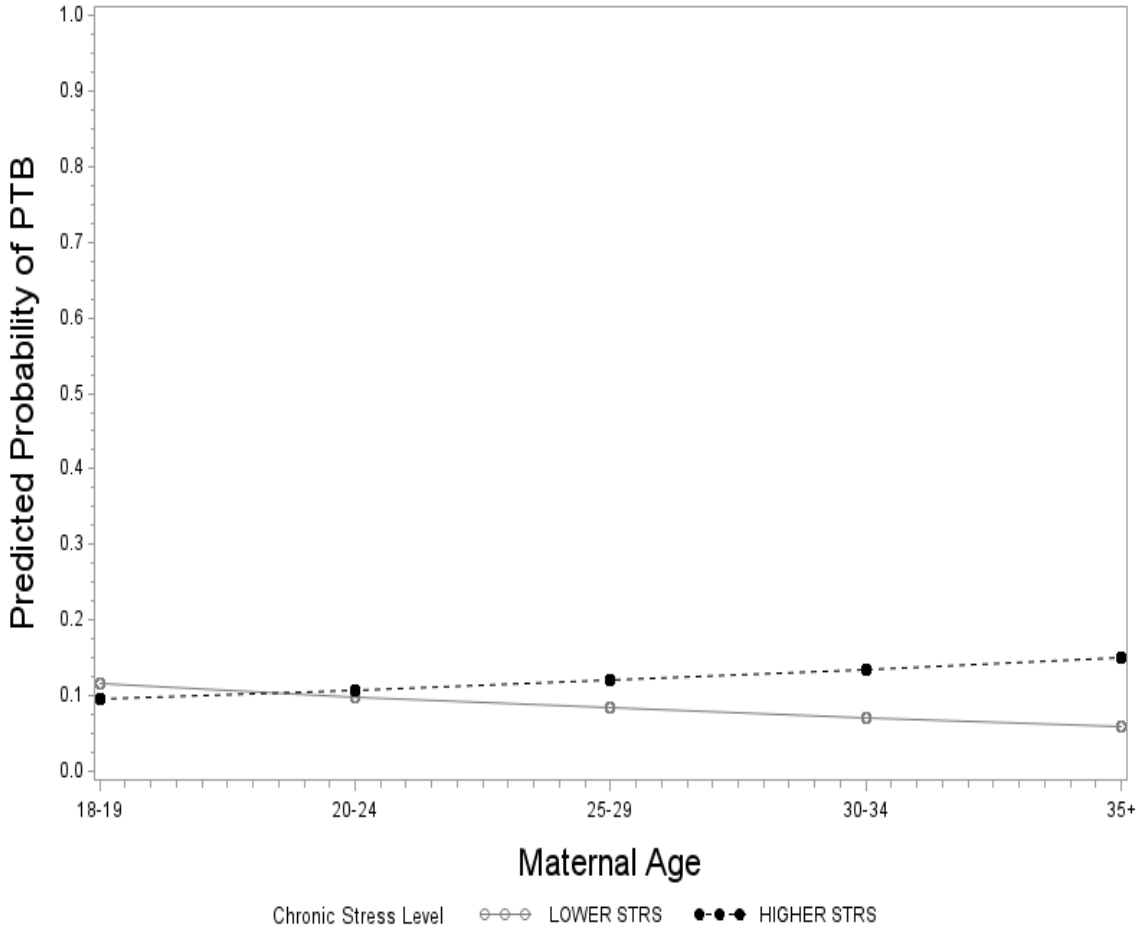

Figure 3. Unadjusted predicted probability of PTB by maternal age and chronic stress among Hispanics

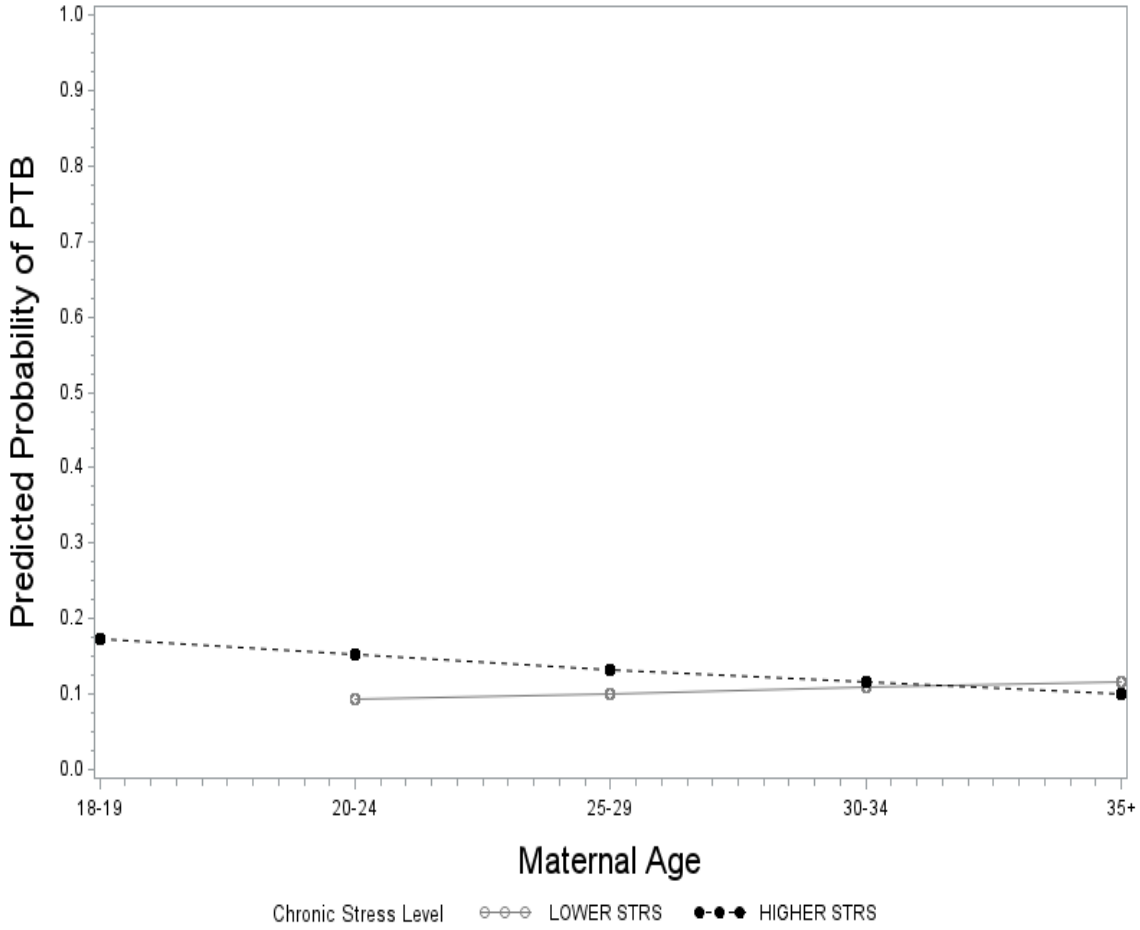

Figure 4. Unadjusted predicted probability of PTB by maternal age and chronic stress among Asians

Table 4.

Odds Ratio of PTB for Maternal Age by the Level of Chronic Stress and Race Bias, Unadjusted and Adjusted for Selected Maternal Risk Factors among Racial/Ethnic Minority Women

	# of PTB case	Unadjusted OR (95% CI)	Adjusted OR[a] (95% CI)
Race bias			
Higher stress	26	1.56 (1.46, 1.66)	1.75 (1.64, 1.88)
Lower stress	7	0.29 (0.23, 0.36)	0.28 (0.23, 0.35)
p value[b]		<.0001	<.0001
No race bias			
Higher stress	125	1.00 (0.98, 1.03)	1.01 (0.98, 1.04)
Lower stress	100	1.02 (0.98, 1.06)	1.03 (0.99, 1.07)
p value		0.5205	0.3376

Note. PTB = preterm birth; OR = adjusted odds ratio; CI = confidence interval.

[a] Adjusted for hypertension during pregnancy, diabetes before and during pregnancy, smoking during pregnancy, prenatal care received in the first trimester, and pregnancy complications.

[b] A *p* value for a maternal age-chronic stress interaction (lower stress group as a reference).

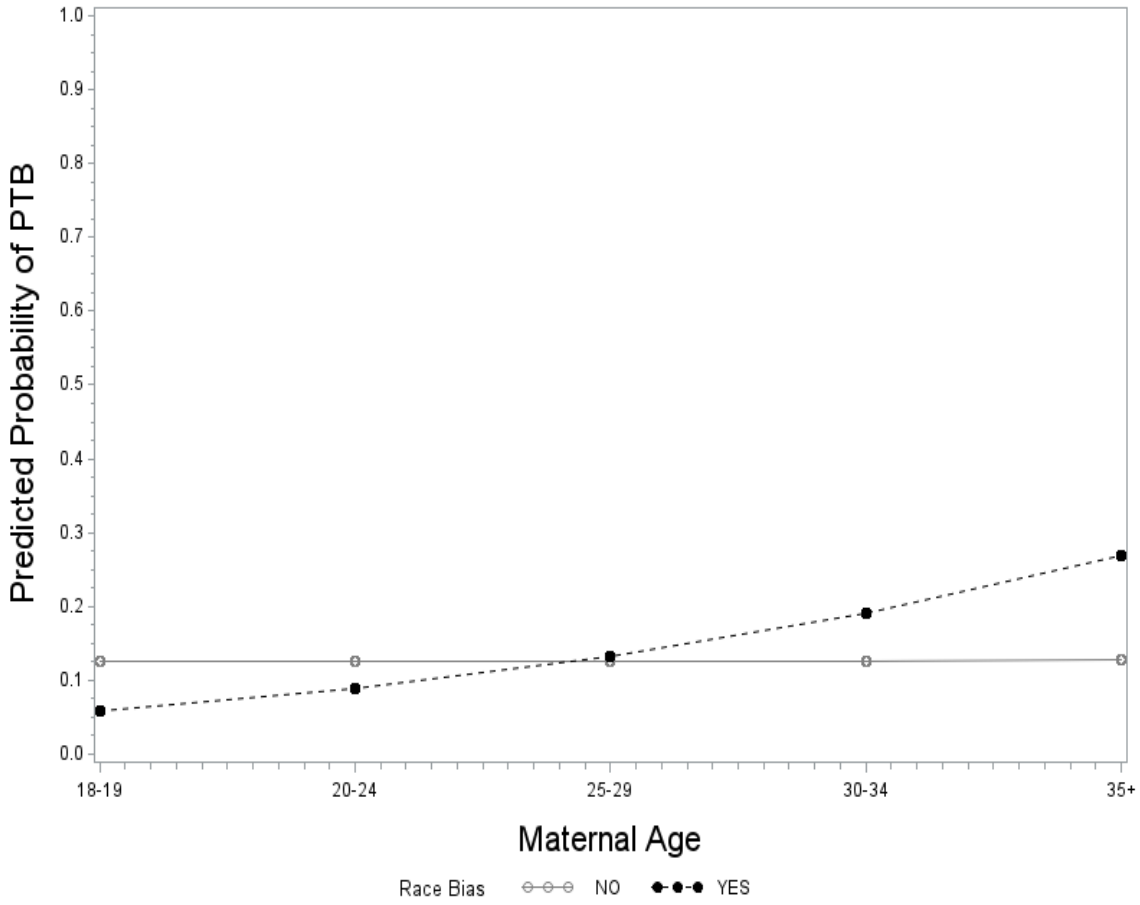

Figure 5. Moderating effect of race bias on the relationship between maternal age and PTB among minority women with high chronic stress

Chapter 5

Summary of Results

This study addressed three specific aims to examine if chronic stress accounts for weathering about PTB among N-H White, N-H Black, Hispanic, and Asian women. Paper 1 sought to identify the known chronic stressors experienced before and during pregnancy that contribute to adverse birth outcomes among racial/ethnic groups of women in the U.S. Paper 2 aimed to examine race/ethnicity-specific dimensionalities of chronic stress and their initial psychometric properties. The hypothesis was that a factor structure of chronic stress differs by race/ethnicity. Of note, a composite index of chronic stress, the operational definition of chronic stress in Paper 3, was developed for individuals based on the underlying factors of chronic stress for each racial/ethnic group. Finally, Paper 3 aimed to investigate the moderating effects of race/ethnicity and maternal age on the relationship between chronic stress and PTB. The hypothesis was that the effect of chronic stress on PTB is significantly different by both race/ethnicity and maternal age.

Paper 1 found that chronic stress has been operationalized in varying ways in the literature. Many of the existing chronic stress measures were limited in their scope, accuracy, and sensitivity to generate inconsistencies in the chronic stress-birth outcome association. They did not capture multiple domains of chronic stress, but mostly external stressors not considering buffers and enhancers of stress as well as perceived stress simultaneously. Also, individual stressors, independent of other stressors, represented

one's chronic stress although stressors usually co-occur. Lastly, few chronic stress measures included unique sources of chronic stress among each racial/ethnic group.

According to Paper 2, the differences in underlying factors of chronic stress before and during pregnancy were indeed evident among four racial/ethnic groups of women regarding significance and experience of certain chronic stressors. Specifically, financial hardship, perceived isolation, and physical violence were the shared sources of chronic stress among four racial/ethnic groups. Racial/ethnic minority groups, however, were more susceptible to the exposure to all three chronic stressors than their N-H White counterparts because they faced multiple jeopardies as female, minority, or immigrant in male-dominating and race-conscious U.S. society. Nevertheless, variations in their chronic stress experiences, particularly those of physical violence were noticeable. For example, a chronic stress burden from physical violence in N-H Black communities was far greater than that in others.

In Paper 3, when chronic stress measures were cumulative and race/ethnicity-specific through a composite index (chronic stress score) that aggregated across the underlying factors of chronic stress unique to each racial/ethnic group, a maternal age-related increase in PTB (i.e., weathering) was observed among not only N-H Black but also N-H White and Hispanic women with high chronic stress. Asian women with high chronic stress, however, showed a reverse weathering pattern (i.e., a decline in PTB with advancing maternal age), which requires further research in the future. Moreover, the moderating effects of race/ethnicity and maternal age on the chronic stress-PTB association held as such the effect of chronic stress on PTB increased with maternal age,

and a gradient existed in weathering among N-H White, N-H Black, and Hispanic women: highest among N-H White, followed by N-H Black and Hispanic women. The experience of race bias, a distinct form of stress from chronic stress, exacerbated the inclining trend of PTB as women aged among racial/ethnic minority women as a whole, particularly those with high chronic stress.

Significance

The current findings contribute to understanding the heterogeneity in chronic stress mechanisms of weathering about PTB among four racial/ethnic groups of women in the U.S. through the improved measurement and conceptualization of chronic stress before and during pregnancy. Specifically, this study identified and overcame the significant limitations of the existing chronic stress measures, such as being culture-insensitive, independent, or less comprehensive by employing the race/ethnicity-specific composite index of chronic stress (Papers 1 and 2). Also, this study disentangled the complex relationships among race/ethnicity, maternal age, chronic stress, and racism underlying the racial/ethnic differences in PTB. It confirmed the moderating effect of maternal age on the chronic stress-PTB relationship (i.e., increasing effect of chronic stress on PTB with advancing maternal age); the altered moderation of maternal age by race/ethnicity; and the exacerbated moderating effect of maternal age in presence of racism among racial/ethnic minority women (Paper 3).

Theoretical Implications

Theoretically, this study finds it promising to apply the weathering framework to disadvantaged women experiencing high levels of chronic stress in diverse settings to

explain their greater risk of PTB, which leads to social or racial/ethnic inequalities in the birth outcome. As mentioned above, this study observed a maternal age-related inclination in PTB among N-H White, N-H Black, and Hispanic women only with a high chronic stress burden before and during pregnancy. The findings about N-H Black women are in general consensus with the existing literature that not all but underprivileged Black women (e.g., those with lifelong residence in deprived neighborhoods) are subject to weathering about adverse birth outcomes (Collins, Rankin, & Hibbs, 2015; Love, David, Rankin, & Collins, 2010). However, this study refutes the premise that weathering is a phenomenon unique to a Black population in the U.S. based on the findings that older N-H White and Hispanic women under high chronic stress are also at greater risk of PTB. Although race/ethnicity is not a significant predictor of weathering, race/ethnicity still plays an essential role in women's health deterioration over time. That said, racial/ethnic differences exist in the magnitude of chronic stress-PTB association across maternal age: the strongest among N-H White, followed by N-H Black and Hispanic women when race bias is not taken into account. In addition, compared to N-H Whites, racial/ethnic minorities are at higher risk of exposure to multiple chronic stressors (e.g., financial hardship, perceived isolation, and physical violence) as well as race bias. The extent of maternal age-related increase in PTB among racial/ethnic minorities experiencing race bias outweighs that among N-H Whites.

Of note, Asian women under high chronic stress do not follow the same weathering pattern observed in other racial/ethnic groups; they rather experience a decrease in PTB with maternal age. To my knowledge, there are only a couple of studies that investigated and documented possible weathering among Asian women (Kim, 2016;

Penfield, Cheng, & Caughey, 2013). Given their research findings, weathering among Asian women under high chronic stress in the current study may have been masked or confounded by such a risk factor as acculturation or by a response bias (e.g., underreporting sensitive and personal issues), which suggests that future research would be beneficial. Another factor worth considering to grasp the reverse weathering among Asian women is their distinctive age pattern of first childbirth, postponed to older ages to a great extent relative to other racial/ethnic groups. It is possible that benefits of delayed childbearing among Asian women could cancel out the harms of their cumulative chronic stress since one's reproductive potential at the time of childbirth is a final product of her lifelong interactions between stressors and their buffers (Lu & Halfon, 2003).

In summary, this study examined the chronic stress pathways for weathering through identifying the interactive relationship between maternal age and chronic stress, which varies by race/ethnicity and experience of race bias. The weathering theoretical model is useful to examine a progression of women's health risks over the life course in diverse contexts. Acknowledging heterogeneity of the chronic stress mechanism among populations may make this theoretical framework more applicable to various groups of women suffering from parallel or variant manifestations of chronic stress as the same fundamental cause (Geronimus & Snow, 2013).

Research Implications

Despite the significance and strength of the current study, future research is guaranteed to ascertain the variance in chronic stress pathways to PTB among racial/ethnic groups, which was not clearly answered in this study. First, such information

as nativity, duration of U.S. residence, and acculturation level should be included to illuminate the chronic stress mechanisms of PTB for Hispanic and Asian women in particular. Considering a longer period lived in the U.S. among immigrant populations may indicate a degradation of their health potential due to cumulative stress from racism or financial difficulties throughout the process of adapting to the new circumstances (Powers, 2013), research questions of particular interest would be if acculturation stress is a component of chronic stress or moderates the effect of chronic stress on adverse birth outcomes across maternal age as does race bias.

Second, it is necessary to incorporate childhood adversity in assessing chronic stress before pregnancy to reflect one's stressful conditions over the life course. Despite mixed results in the literature regarding the effect of preconception chronic stress on PTB (Kramer, Hogue, Dunlop, & Menon, 2011), chronic stressors including poverty, racism, and family dysfunction are generally acknowledged to heighten women's vulnerability to PTB before conception because of the body's malfunctioning neurohormonal regulatory systems to adapt to stress and maintain physiological stability (Patrick & Bryan, 2005). Strutz et al. (2014) documented preconception chronic stressors (e.g., parent's low SES, living without either biological parent, and poor neighborhood), but not acute stressors, significantly lowered birth weight among first and second births. Also, N-H Black, Mexican-origin Latina, and other origin Latina showed higher scores of preconception chronic stress and lower birth weight than did their N-H White counterparts. Thus, an inclusion of factors indicative of childhood adversity will enhance the quality of chronic stress measures; this has the potential to show a significant or stronger influence of chronic stress on adverse birth outcomes.

Third, collecting biomarkers of chronic stress (e.g., blood/hair cortisol, pro-inflammatory cytokines, telomeres, or microbiome) holds a great potential to elucidate racial/ethnic differentials in not only exposure to chronic stressors but also responses to chronic stress. Menon (2009) underlined the necessity of personalized risk assessment to better understand the disparities in PTB among racial/ethnic groups since risk factors and biomarkers for PTB are not the same across populations. In addition to obtaining objective data on the level of chronic stress experienced, biomarkers enable one to develop, target, and evaluate tailored interventions more precisely; as such, the implemented programs can potentially eliminate sources of chronic stress or buffer the harm of chronic stress for individuals in varying racial/ethnic communities (Corwin & Ferranti, 2016).

Fourth, a structural equation modeling (SEM) approach will be conducted to confirm the factor structure of chronic stress before and during pregnancy for each of the four racial/ethnic groups; and to examine the relationships among the latent factors of chronic stress and between the latent factors and PTB as an outcome. Although Paper 2 did not show high correlations among the three latent factors of chronic stress within the racial/ethnic groups, SEM will provide useful information on which model fits the data and predicts PTB better between a higher-order model and an alternative model. The former hypothesizes an existence of a global chronic stress factor comprised of the three latent subfactors (i.e., financial hardship, perceived isolation, and physical violence). The latter hypothesizes that each of these latent factors independently predicts PTB. Using a SEM approach also accounts for any measurement error that might influence the outcomes of interests.

Nursing Implications

This study laid a theoretical basis for developing culturally competent preventive strategies targeting specific racial/ethnic groups and sources of chronic stress before and during pregnancy in the U.S. To relieve a chronic stress burden of racial/ethnic minority groups of women, more efforts should be devoted to intervening with their physical violence and perceived isolation. Notably, priority should be given to physical violence in N-H Black communities and perceived isolation in Hispanic/Asian communities despite the significance of both issues in the lives of racial/ethnic minority women. As mentioned before, physical violence is significant in many communities, with the highest percentage occurring in Black women in the U.S. At the national level, 41.2% of N-H Black, 30.5% of N-H White, 29.7% of Hispanic, and 15.3% of Asian or Pacific Islander women were estimated to experience physical violence by their intimate partner during the lifetimes in 2011 (Breiding, 2015). Despite knowledge of formal support systems, N-H Black women, especially those in poverty may not be able to access needed services. Physical violence in Black communities may persist as victims tend to protect their abusers from the law enforcement by not disclosing the occurrence of physical assaults to others; such that they do not aggravate the systematic mistreatment of Black populations in society (e.g., police brutality; Yoshioka, Gilbert, El-Bassel, & Baig-Amin, 2003). For Hispanic and Asian immigrant women, perceived isolation increases their chances to be victims of physical violence. As a result of immigration, many immigrant women experience a disconnect from the social support previously provided by their extended families and communities (Kasturirangan, Krishnan, & Riger, 2004). In this circumstance, it is not easy for an immigrant woman to leave her abusive spouse who can provide

companionship and a connection to her country of origin and help to navigate everyday situations in a new country (Kasturirangan et al., 2004).

Specifically, it would be instructive to develop a risk algorithm for chronic stress unique to each racial/ethnic group. Then, screening for chronic stress should be implemented as part of a regular care plan in the field of women's health over the life course (e.g., during wellness, prenatal, postpartum, and internatal care). Of importance, available services should be available, accessible, and affordable to assist women screened positive. Indeed, a lack of support services for IPV victims has been acknowledged as an obstacle for care providers to screen for women's IPV (Lu et al., 2006). For many battered Hispanic and Asian women, necessary material, informational, and legal resources are less accessible to deal with their stressful situations, which is attributable to cultural and language barriers in utilizing them (Bauer, Rodriguez, Quiroga, & Flores-Ortiz, 2000; Lee & Hadeed, 2009). This calls for relevant agencies or institutions reaching out to specific racial/ethnic communities and providing women with a history of or ongoing physical abuse with culturally tailored resources and services. Indeed, prevention messages of physical violence must have meaning within the context of the target communities beyond a simple translation of the words into different languages (Kasturirangan et al., 2004). Further, nurses in clinical and community settings can work as advocates for battered women by empowering them to organize grassroots resistance against violence in their communities or supporting local grassroots efforts through sharing resources and working in collaboration with trusted community groups (Kasturirangan et al., 2004).

Besides, nursing interventions to foster women's resilience in the context of chronic stress should be designed for racial/ethnic or age groups. Resilience is defined as "the process involving an ability to withstand and cope with ongoing or repeated demands and maintain healthy functioning in different domains of life such as work and family" (Dunkel Schetter & Dolbier, 2011, p. 637). Resilience resources (e.g., personality and dispositional resources, self and ego-related resources, interpersonal and social resources, world views and culturally-based beliefs and values, behavioral and cognitive skills, and other resources) vary among individuals and groups (Dunkel Schetter & Dolbier, 2011). Nevertheless, less is examined on which resilience resources are relevant to racial/ethnic or age groups (Dunkel Schetter, 2011; Hurtado-de-Mendoza, Gonzales, Serrano, & Kaltman, 2014). Dunkel Schetter (2011) asserted that maternal race/ethnicity, cultural values, and the particular type of support are important moderators of the effect of stress on birth weight. Reyes and Constantino (2016) also argued that resilience is developmentally different among age groups (e.g., adolescent vs. adult), which implies the necessity of resilience-nurturing programs tailored to specific age groups and further research to test this hypothesis.

The behavioral and mental health interventions that have been implemented by far, including physical relaxation and meditation, assessment and education, and counseling and social support have garnered limited success to reduce the risk of adverse birth outcomes through stress reduction (Hawkley & Cacioppo, 2010; Hobel, Goldstein, & Barrett, 2008). This may be because those interventions were designed without deeper understanding of which resources constitute resilience in specific situations and

populations; how they operate; and who will exhibit the most adaptive responses (Dunkel Schetter & Dolbier, 2011; Hurtado-de-Mendoza et al., 2014).

Thus, the effectiveness of interventions to strengthen resilience of racial/ethnic minority groups of women under high chronic stress will be improved with the knowledge of what methods (pregnant) women of particular race/ethnicity use to manage stress in their lives and what works or does not work for them (Dunkel Schetter, 2011). Answers to the following questions may be helpful to design the tailored interventions: "What critical resources are specific subgroups of pregnant women most likely to possess or lack? Do they try to conserve and replenish their resources? Can resources be strengthened during pregnancy to influence birth outcomes, or is the building of resources something that must take place preconception?" (Dunkel Schetter, 2011, p. 547). Given the nature of such research questions, a community-based participatory approach may yield effective interventions at the community level by incorporating members of particular racial/ethnic minority or age groups from the stage of problem identification through program design to program delivery and evaluation (Hurtado-de-Mendoza et al., 2014).

Further, in clinical settings, nurses need to reflect and challenge their assumptions about the culture-resilience relationship to provide culturally competent health care to marginalized racial/ethnic minority women. According to Reyes and Constantino (2016), the same ethnicity among Asian American Pacific Island women were not necessarily supportive of one another; their immigration experience was not only a source of trauma but also an enhancer of resilience, which is antithetical to the common assumptions. By

examining their biases out of consciousness, nurses can communicate with racial/ethnic minority women experiencing chronic stress in a culturally sensitive fashion, which leads to objective assessment of the patient's weakness and strength to deal with her chronic stress and active engagement of the patient into her care plans.

Conclusions

The detrimental impact of chronic stress does not end at the time of delivery. Rather, its effect lasts longer, carrying over to the postpartum period and may affect parental dysfunction (e.g., parenting stress, child abuse, physically punitive behavior, and parental disengagement) that could lead to infant's development, physical and mental health outcomes, and even death (Cardwell, 2013; Ramey et al., 2015). High burdens of chronic stress in racial/ethnic communities could perpetuate or even widen the racial/ethnic disparities in PTB in the U.S. as more women delay their first childbirth across race/ethnicity (Matthews & Hamilton, 2014; Rauh, 2001). This study will ultimately contribute to alleviating such disparities through elaborating the chronic stress model and developing theory-driven, race/ethnicity-specific interventions to build or restore women's resilience resources over the life course.

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